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1915

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The Royal Society of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors of papers desiring illustrations, are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is $4\frac{1}{4}$ in. $\times$ $6\frac{3}{4}$ in. The cost of all original drawings, and of colouring plates must be borne by Authors.

FORM OF BEQUEST.

I bequeath the sum of £ to the Royal Society of New South Wales, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

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OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Transactions or Journal; papers published in the Transactions of the Philosophical Society are also included. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1908		Abbott, George Henry, B.A., M.B., Ch.M., Macquarie-street; p.r. 'Cooringa,' 252 Liverpool Road, Summer Hill.
1877	P 5	Abbott, W. E., 'Abbotsford,' Wingen.
1904		Adams, William John, M. I. MECH. E., 175 Clarence-street.
1898		Alexander, Frank Lee, c/o Messrs. Goodlet and Smith Ltd., Cement Works, Granville.
1905		Anderson, Charles, M.A., D.Sc. *Edin.*, Australian Museum, College-street.
1909	P 7	Andrews, E. C., B.A., F.G.S., Geological Surveyor, Department of Mines, Sydney.
1915		Armit, Henry William, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 30-34 Elizabeth-street.
1878		Backhouse, His Honour Judge A. P., M.A., 'Melita,' Elizabeth Bay.
1894	P 22	Baker, Richard Thomas, F.L.S., Curator, Technological Museum.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1896		Barff, H. E., M.A., Warden of the University of Sydney.
1908	P 1	Barling, John, L.S., 'St. Adrians,' Raglan-street, Mosman.
1895	P 9	Barraclough, S. Henry, B.E., M.M.E., ASSOC. M. INST. C.E., M. I. MECH. E., Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Professor of Mechanical Engineering in the University of Sydney; p.r. 'Marmion,' Victoria-street, Lewisham.
1906		Basnett, Nathaniel James, Punch-st., Mosman.
1894		Baxter, William Howe, L.S., Chief Surveyor, Existing Lines Office, Railway Department, Bridge-street.
1877		Belfield, Algernon H., 'Eversleigh,' Dumaresq.
1909	P 2	Benson, William Noel, D.Sc., The University, Sydney.
1913		Bishop, Joseph Eldred, Killarney-street, Mosman.
1915		Bishop, John, 24 Bond-street.
1905		Blakemore, George Henry, 4 Bridge-street.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, Fremantle, West Australia.
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1898		Blunno, Michele, Licentiate in Science (Rome), Government Viticultural Expert, Department of Agriculture, Sydney.

Elected		
1907		Bogenrieder, Charles, M.A., No. 2 Little's Avenue, Balmain.
1879		‡Bond, Albert, 131 Bell's Chambers, Pitt-street.
1910		Bradley, Clement Henry Burton, M.B., Ch.M., D.P.H., Demonstrator in Physiology in the University of Sydney.
1876		Brady, Andrew John, L.K. and Q.C.P. *Irel.*, L.R.C.S. *Irel.*, 175 Macquarie-street, Sydney.
1891		Brennand, Henry J. W., B A., M.B., Ch.M. *Syd.*, 'The Albany,' Macquarie-st., p.r. 'Wobun,' 310 Miller-st., North Sydney.
1914		Broad, Edmund F., 'Cobbam,' Woolwich Road, Hunter's Hill.
1878		‡Brooks, Joseph, J.P., L.S., F.R.A.S., F.R.G.S., 'Hope Bank,' Nelson-street, Woollahra.
1913	P 1	Browne, William Rowan, B.Sc., Assistant Lecturer and Demonstrator in Geology in the University, Sydney.
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Aberdour,' Daniel-street, Granville.
1898		‡Burfitt, W. Fitzmaurice, B.A., B.Sc., M.B., Ch.M. *Syd.*, 'Wyoming,' 175 Macquarie-street, Sydney.
1890		Burne, Alfred, D.D.S., Buckland Chambers, 183 Liverpool-st.
1907		Burrows, Thomas Edward, M. INST. C.E., L.S., Metropolitan Engineer, Public Works Department; p.r. 'Balboa,' Fern-street, Randwick.
1909		Calvert, Thomas Copley, ASSOC. M. INST. C.E., 'Maybank,' Manly.
1904	P 8	Cambage, Richard Hind, L.S., F.L.S., Under Secretary for Mines, Department of Mines, Sydney; p.r. Park Road, Burwood. (President 1912-13). *Hon. Secretary.*
1907		Campbell, Alfred W., M.D., Ch.M. *Edin.*, 183 Macquarie-street.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliffe Rd., Edgecliffe.
1897	P 4	Cardew, John Haydon, M. INST. C.E., L.S., 75 Pitt-street.
1901		Card, George William, A.R.S.M., F.G.S., Curator and Mineralogist to the Geological Survey, Department of Mines, Sydney.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.* F.F.A., *Scot.*, 4 Whaling Road, North Sydney. *Vice-President.*
1909		Carne, Joseph Edmund, F.G.S., Government Geologist, Department of Mines, Sydney.
1903	P 1	Carslaw, H. S., M.A., Sc.D., Professor of Mathematics in the University of Sydney.
1913	P 2	Challinor, Richard Westman, F.I.C., F.C.S., Lecturer in Chemistry, Sydney Technical College.
1909	P 2	Chapman, H. G., M.D., B.S., Assistant Professor of Physiology in the University of Sydney. *Hon. Treasurer.*
1913	P 4	Cheel, Edwin, Botanical Assistant, Botanic Gardens, Sydney.
1909	P 16	Cleland, John Burton, M.D., Ch.M., Principal Assistant Microbiologist, Department of Public Health, 93 Macquarie-st.
1913		Cooke, William Ernest, M.A., F.R.A.S., Government Astronomer and Professor of Astronomy in the University of Sydney, The Observatory, Sydney.
1896	P 2	Cook, W. E., M.C.E. *Melb.*, M. INST. C.E., Water and Sewerage Board, North Sydney.
1904	P 2	Cooksey, Thomas, Ph.D., B.Sc. *Lond.*, F.I.C., Government Analyst; p.r. 'Clissold,' Calypso Avenue, Mosman.

Elected		
1913		Coombs, F. A., F.C.S., Instructor of Leather Dressing and Tanning, Sydney Technical College; p.r. 55 Willoughby Road, North Sydney.
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L R.C.P. *Lond.*, L.R.C.P. *Edin.*, 'Roseneath,' 8 Wallis-street, Woollahra.
1906		Colley, David John K., Superintendent, Royal Mint, Sydney.
1882		Cornwell, Samuel, J.P., Brunswick Road, Tyagarah.
1909	P 2	Cotton, Leo Arthur, M.A., B.Sc., Assistant Lecturer and Demonstrator in Geology in the University of Sydney.
1892	P 1	Cowdery, George R., ASSOC. M. INST. C.E., Blashki Buildings, Hunter-st.; p,r. 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 185 Macquarie-st.
1912		Curtis, Louis Albert, L.S., 'Redlands,' Union-street, Mosman.
1875		Dangar, Fred. H., c/o W. E. Deucher, 12 and 14 Loftus-street.
1890		Dare, Henry Harvey, M.E., M. INST. C.E., Water Conservation and Irrigation Commission, 29 Elizabeth-street, Sydney.
1876	P 3	Darley, Cecil West, M. INST. C.E., Australian Club, Sydney.
1910		Darnell-Smith, George Percy, B.Sc., F.I.C., F.C.S., Department of Agriculture, Sydney.
1886	P 21	David, T. W. Edgeworth, C.M.G., B.A., D.Sc., F.R.S., F.G.S., Professor of Geology and Physical Geography in the University of Sydney. (President 1895-96, 1910-11.)
1909		Davidson, George Frederick.
1892	P 1	Davis, Joseph, M. INST. C.E., Director-General, Public Works Department, Sydney.
1885	P 3	Deane, Henry, M.A., M. INST. C.E., F.L.S., F.R. MET. SOC., F.R.H.S., 'Campsie,' 14 Mercer Road, Malvern, Victoria. (President 1897-98, 1907-8.)
1894		Dick, James Adam, B.A. *Syd.*, M.D., Ch.M., F.R.C.S. *Edin.*, 'Catfoss,' Belmore Road, Randwick.
1915	P 1	Dick, Thomas, J.P., Port Macquarie.
1875	P 12	Dixon, W. A., F.I.C., F.C.S., 'Girton,' McLaren-st., North Sydney.
1906		Dixson, William, 'Merridong,' Gordon Road, Killara.
1876		Docker, His Honour Judge E. B., M.A., 'Mostyn,' Billyard Avenue, Elizabeth Bay.
1913		Dodd, Sydney, D.V.Sc., F.R.C.V.S., Lecturer in Veterinary Pathology in the University of Sydney.
1913	P 2	Doherty, William M., Analyst, Department of Public Health, Sydney.
1908	P 3	Dun, William S., Palæontologist, Department of Mines.
1908		Esdaile, Edward William, 54 Hunter-street.
1879	P 4	Etheridge, Robert, Junr., J.P., Curator, Australian Museum; p.r. 'Inglewood,' Colo Vale, N.S.W.
1896		Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street.
1868		Fairfax, Sir James R., Knt., *S. M. Herald* Office, Hunter-st.
1887		Faithfull, R. L., M.D., *New York*, L.R.C.P., L.S.A. *Lond.*, 'Wilga,' 18 Wylde-street, Potts Point.

Elected		
1902		Faithfull, William Percy, Australian Club.
1910		Farrell, John, Assistant Teacher, Sydney Technical College; p.r. 8 Thompson-street, Darlinghurst.
1909	P 1	Fawsitt, Charles Edward, D.Sc., PH.D., Professor of Chemistry in the University of Sydney.
1881		Fiaschi, Thos., M.D., M.Ch. *Pisa.*
1915		Finckh, A. E., M.B., 227 Macquarie-street.
1888		Fitzhardinge, His Honour Judge G. H., M.A., 'Red Hill,' Beecroft.
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1905		Foy, Mark, 'Eumemering,' Bellevue Hill, Woollahra.
1904		Fraser, James, M. INST. C.E., Engineer-in-Chief for Existing Lines, Bridge-street; p.r. 'Arnprior,' Neutral Bay.
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1899		French, J. Russell, General Manager, Bank of New South Wales, George-street.
1881		Furber, T. F., F.R.A.S., c/o Dr. R. J. Furber, 'Sunnyside,' Stanmore Road, Stanmore.
1906		Gosche, W. A. Hamilton, 24½ Pitt-street, Sydney.
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1907		Green, W. J., Chairman, Hetton Coal Co., Athenæum Club.
1899		Greig-Smith, R., D.Sc. *Edin.*, M.Sc. *Dun.*, Macleay Bacteriologist, Linnean Society's House, Ithaca Road, Elizabeth Bay.
1912		(President 1915-16.)
1912		Grieve, Robert Henry, B.A., 'Langtoft,' Llandaff-st., Waverley.
1891	P 16	Griffiths, F. Guy, B.A., M.D., CH.M., 135 Macquarie-st., Sydney.
		Guthrie, Frederick B., F.I.C., F.C.S., Chemist, Department of Agriculture, 137 George-street, Sydney. (President 1903-4).
1880	P 4	Halligan, Gerald H., L.S., F.G.S., 'Riversleigh,' Hunter's Hill.
1912		Hallmann, E. F., B.Sc., Biology Department, The University, Sydney.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1909		Hammond, Walter L., B.Sc., Hurlstone Avenue, Summer Hill.
1912		Hamilton, A. G., Lecturer on Nature Study, Teachers' College, Blackfriars.
1887	P 8	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; 'Strathallen,' Blaxland Ridge, viâ Richmond, N.S.W. (President 1899-1900, 1908-9).
1912		Hare, A. J., Under Secretary for Lands, 'Booloorool,' Monte Christo-street, Woolwich.
1905	P 1	Harker, George, D.Sc.. Assistant Lecturer and Demonstrator in Organic Chemistry in the University of Sydney.
1913	P 1	Harper, Leslie F., F.G.S., Geological Surveyor, Department of Mines, Sydney.
1884	P 1	Haswell, William Aitcheson, M.A., D.Sc., F.R.S., Professor of Zoology and Comparative Anatomy in the University of Sydney; p.r. 'Mimihau,' Woollahra Point.
1900		Hawkins, W. E., 88 Pitt-street.

Elected		
1914		Hector, Alex. Burnet, 481 Kent-street.
1891	P 3	Hedley, Charles, F.L.S., Assistant Curator, Australian Museum, Sydney. *Vice-President.* (President 1914-15.)
1899		Henderson, J., F.R.E.S., Manager, City Bank of Sydney, Pitt-st.
1884	P 1	Henson, Joshua B., ASSOC. M. INST. C.E., Hunter District Water Supply and Sewerage Board, Newcastle.
1905		Hill, John Whitmore, 'Willamere,' May's Hill, Parramatta.
1914		Hoare, Robert R., Staff Paymaster, Royal Navy, Garden Island, Sydney.
1892		Hodgson, Charles George, 157 Macquarie-street.
1901		Holt, Thomas S., 'Amalfi,' Appian Way, Burwood.
1905		Hooper, George, Assistant Superintendent, Sydney Technical College; p.r. 'Banksome,' Henson-street, Summer Hill.
1891		Houghton, Thos. Harry, M. INST. C.E., M. I. MECH. E., 63 Pitt-st.
1906	P 2	Howle, Walter Cresswell, L.S.A. *Lond.*, Bradley's Head Road, Mosman.
1913		Hudson, G. Inglis, J.P., 'Gudvangen,' Arden-street, Coogee.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Chief Inspector of Mines, Department of Mines.
1905	P 8	Jensen, Harold Ingemann, D.Sc., Government Geologist, Darwin, Northern Territory.
1907		Johnson, T. R., M. INST. C.E.
1909	P 13	Johnston, Thomas Harvey, M.A., D.Sc., F.L.S., Lecturer in Biology in the University of Queensland, Brisbane.
1867		Jones, Sir P. Sydney, Knt., M.D. *Lond.*, F.R.C.S. *Eng.*, 'Llandilo, Boulevarde, Strathfield.
1911		Julius, George A., B.Sc., M.E., M. I. MECH. E., Culwulla Chambers, Castlereagh-street, Sydney.
1907		Kaleski, Robert, Holdsworthy, Liverpool.
1883		Kater, The Hon. H. E., J.P., M.L.C., Australian Club.
1873	P 3	Keele, Thomas William, L.S., M. INST. C.E., Commissioner, Sydney Harbour Trust, Circular Quay; p.r. Llandaff-st., Waverley.
1914		Kemp, William E., A.M. INST. C.E., Public Works Department, Sydney.
1887		Kent, Harry C., M.A., F.R.I.B.A., Dibbs' Chambers, Pitt-street.
1901		Kidd, Hector, M. INST. C.E., M. I. MECH. E., Cremorne Road, Cremorne.
1896		King, Kelso, 120 Pitt-street.
1878		Knaggs, Samuel T., M.D. *Aberdeen*, F.R.C.S. *Irel.*, 'Northcote,' Sir Thomas Mitchell Road, Bondi.
1881	P 23	Knibbs, G. H., L.S., C.M.G., F.S.S., F.R.A.S., Member Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild; Commonwealth Statistician, Melbourne. (President 1898-99.)
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1913		Kuntzen, Harold Eric.
1911	P 2	Laseron, Charles Francis, Technological Museum.
1913		Lawson, A. Anstruther, D.Sc., F.R.S.E., Professor of Botany in the University of Sydney.

Elected		
1906		Lee, Alfred, 'Glen Roona,' Penkivil-street, Bondi.
1909		Leverrier, Frank, B.A., B.Sc. K.C., 182 Phillip-street.
1914		Lightoller, G. H. Standish, M.B., Ch.M., 'Yetholm," New South Head Road, Darling Point.
1883		Lingen, J. T., M.A. *Cantab.*, University Chambers, 167 Phillip-street, Sydney.
1906		Loney, Charles Augustus Luxton, M. AM. SOC. REFR. E., Equitable Building, George-street.
1911		Longmuir, G. F., B.A., Science Master, Technical College, Bathurst.
1912		Lovell, Henry Tasman, M.A., Ph.D., 'Tane,' Hodson Avenue, Cremorne.
1884		MacCormick, Sir Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street, North.
1887		MacCulloch, Stanhope H., M.B., Ch.M, *Edin.*, 24 College-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co, Ld., 2 Spring-street.
1903		McDonald, Robert, J.P., Pastoral Chambers, O'Connell-street; p.r. 'Wairoa.' Holt-street, Double Bay,
1891		McDouall, Herbert Chrichton, M.R.C.S. *Eng.*, L.R.C.S. *Lond.*, D.P.H. *Cantab.*, Hospital for the Insane, Gladesville.
1906		McIntosh, Arthur Marshall, 'Glenbourne,' Hill-st., Roseville.
1891	P 2	McKay, R. T., L.S., ASSOC. M. INST. C.E., Geelong Waterworks and Sewerage Trusts Office, Geelong, Victoria.
1876		Mackellar, The Hon. Sir Charles Kinnaird, M.L.C.. M.B., C.M. *Glas.*, Equitable Building, George-street.
1880	P 9	McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M. INST. C.E., Sydney Safe Deposit, Paling's Buildings, Ash-street.
1912	P 1	MacKinnon, Ewen, B.Sc., Agricultural Museum, George-st. N.
1903		McLaughlin, John, Union Bank Chambers, Hunter-street.
1901	P 1	McMaster, Colin J., L.S., Chief Commissioner of Western Lands; p.r. Wyuna Road, Woollahra Point.
1894		McMillan, Sir William, K.C.M.G., 'Darrah,' 311 Edgecliff Road, Woollahra.
1899		MacTaggart, J. N. C., M.E. *Syd.*, ASSOC. M. INST. C.E., Water and Sewerage Board District Office, Lyons Road, Drummoyne.
1909		Madsen, John Percival Vissing, D.Sc., B.E., P. N. Russell Lecturer in Electrical Engineering in the University of Sydney.
1883	P 29	Maiden, J. Henry, J.P., F.R.S., F.L.S., F.R.H.S., Hon. Fellow Roy. Soc. S.A.; Hon. Memb. Royal Society, W.A.; Netherlands Soc.for Promotion of Industry; Philadelphia College Pharm. Southern Californian Academy of Sciences; Pharm. Soc. N.S.W.; Brit. Pharm. Conf.; Corr. Fellow Therapeutical Soc., Lond.; Corr. Memb. Pharm. Soc. Great Britain; Bot. Soc. Edin.; Soc Nat. de Agricultura (Chile); Soc. d' Horticulture d' Alger; Union Agricole Calédonienne; Soc. Nat. etc., de Chérbourg; Roy. Soc. Tas.; Roy. Soc. Queensl.; Inst. Nat. Genévois; Hon. Vice-Pres. of the Forestry Society of California; Diplomé of the Société Nationale d'Acclimatation de France; Linnean Medallist, Linnean Society; N.S.W. Govt. Rep. of the "Commission Consultative pour la Protection Internat. de la Nature"; Government Botanist and Director, Botanic Gardens, Sydney. *Vice-President.* (President 1896-7, 1901-2, 1911-12.)

Elected		
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1897		Marden, John, M.A., LL.D., Principal, Presbyterian Ladies' College, Croydon, Sydney.
1908		Marshall, Frank, B.D.S. *Syd.*, 'Beanbah,' 235 Macquarie-street.
1914		Martin, A. H., 'Glengarriff,' Nea-street, Chatswood.
1875	P 27	Mathews, Robert Hamilton, L.S., Assoc. Etran. Soc. d' Anthrop. de Paris; Cor. Mem. Anthrop. Soc., Washington, U.S.A.; Corr, Mem. Anthrop. Soc. Vienna; Corr. Mem. Roy. Geog. Soc. Aust. Q'sland; Local Correspondent Roy. Anthrop. Inst., Lond.; 'Carcuron,' Hassall-st., Parramatta.
1903		Meggitt, Loxley, Co-operative Wholesale Society, Alexandria.
1912		Meldrum, Henry John, p.r. 'Craig Roy,' Sydney Rd., Manly.
1905		Miller, James Edward, Broken Hill, New South Wales.
1889	P 8	Mingaye, John C. H., F.I.C., F.C.S., Assayer and Analyst to the Department of Mines, p.r. Campbell-street, Parramatta.
1879		Moore, Frederick H., Union Club, Sydney, c/o Dalgety's Ltd., London.
1879		Mullins, John Francis Lane, M.A. *Syd.*, 'Killountan,' Darling Point.
1915		Murphy, R. K., Dr. Ing., Chem. Eng., Consulting Chemical Engineer and Lecturer in Chemistry, Technical College, Sydney.
1876		Myles, Charles Henry, 'Dingadee,' Everton Rd., Strathfield.
1893	P 3	Nangle, James, F.R.A.S., Superintendent of Technical Education, The Technical College, Sydney; p.r. 'St. Elmo,' Tupper-street, Marrickville.
1891		‡Noble, Edward George, L.S., 8 Louisa Road, Balmain.
1893		Noyes, Edward, ASSOC. INST. C.E., ASSOC. I. MECH. E., c/o Messrs. Noyes Bros., 115 Clarence-street, Sydney.
1903		‡Old, Richard, 'Waverton,' Bay Road, North Sydney.
1913		Ollé, A. D., 'Kareema,' Charlotte-street, Ashfield.
1896		Onslow, Col. James William Macarthur, 'Gilbulla,' Menangle.
1875		O'Reilly, W. W. J., M.D., Ch.M., Q. Univ. *Irel.*, M.R.C.S. *Eng.*, 171 Liverpool-street, Hyde Park.
1891		Osborn, A. F., ASSOC. M. INST. C.E., Water Supply Branch, Sydney, 'Uplands,' Meadow Bank, N.S.W.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1878		Paterson, Hugh, 183 Liverpool-street, Hyde Park.
1901		Peake, Algernon, M. INST. C.E., L.S., 25 Prospect Road, Ashfield.
1899		Pearse, W., Union Club; p.r. 'Plashett,' Jerry's Plains, viâ Singleton.
1877		Pedley, Perceval R., Lord Howe Island.
1899		Petersen, T. Tyndall, F.C.P.A., 4 O'Connell-street.
1909	P 1	Pigot, Rev. Edward F., S.J., B.A., M.B. *Dub.*, Director of the Seismological Observatory, St. Ignatius' College, Riverview.
1879	P 7	Pittman, Edward F., ASSOC. R.S.M., L.S., Uuder Secretary for Mines, 'Carnarvon,' Bayswater Road, Darlinghurst.

Elected		
1881		Poate, Frederick, L.S., Surveyor-General, Lands Department, Sydney.
1879		Pockley, Thomas F. G., Union Club, Sydney.
1887	P 10	Pollock, J. A., D.Sc., F.R.S., Corr. Memb. Roy. Soc. Tasmania; Roy. Soc. Queensland; Professor of Physics in the University of Sydney. *Hon. Secretary.*
1896		Pope, Roland James, B.A., *Syd.*, M.D., C.M., F.R.C.S., *Edin.*, 183 Macquarie-street.
1910		Potts, Henry William, F.L.S., F.C.S., Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1914		Purdy, John Smith, M.D., C.M. *Aberd.*, D.P.H. *Camb.*, Metropolitan Medical Officer of Health, Town Hall, Sydney.
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 139 Macquarie-street.
1901	P 1	Purvis, J. G. S., ASSOC. M. INST. C.E., Water and Sewerage Board, 341 Pitt-street.
1908		Pye, Walter George, M.A., B.Sc.. 'Gainsford Lodge,' 331 Ernest-street, North Sydney.
1876	P 1	Quaife, F. H., M.A., M.D., M.S., 'Yirrimbirri,' Stanhope Road, Killara. *Vice-President.*
1912	P 2	Radcliff, Sidney, Radium Hill Works, Woolwich.
1890	P 1	Rae, J. L. C.. 'Lisgar,' King-street, Newcastle.
1865	P 1	‡Ramsay, Edward P., LL.D. *St. And.*, F.R.S.E., F.L.S., Queensborough Road, Croydon Park.
1906		Redman, Frederick G., P. and O. Office, Pitt-street.
1914		Rhodes, Thomas, Civil Engineer, Public Works Department, Sydney.
1909		Reid, David, 'Holmsdale,' Pymble.
1902		Richards, G. A., Mount Morgan Gold Mining Co., Mount Morgan, Queensland.
1906		Richardson, H. G. V., 32 Moore-street.
1913	P 2	Robinson, Robert, D.Sc.. Professor of Organic Chemistry in the University of Sydney.
1915		Ross, A. Clunies, B.Sc., C. of E. Grammar School, North Sydney.
1913		Roseby, Rev. Thomas, M.A., LL.D. *Syd.*, F.R.A.S., 'Tintern,' Mosman.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, 151 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1897		Russell, Harry Ambrose, B.A., c/o Messrs. Sly and Russell, 369 George-street; p.r. 'Mahuru,' Fairfax Road, Bellevue Hill.
1893		Rygate, Philip W., M.A., B.E. *Syd.*, ASSOC. M. INST. C.E., L.S., City Bank Chambers, Pitt-street, Sydney.
1915		Sach, A. J., F.C.S., 'Kelvedon,' North Road, Ryde.
13		Scammell, W. J., Mem. Phar. Soc. *Grt. Brit.*, 18 Middle Head Road, Mosman.
05		Scheidel, August, Ph.D., Managing Director, Commonwealth Portland Cement Co., 4 O'Connell-street.

Elected		
1892	P 1	Schofield, James Alexander, F.C.S., A.R.S.M., Assistant Professor of Chemistry in the University of Sydney.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Archer-street, Chatswood.
1904	P 1	Sellors, R. P., B.A. *Syd.*, 'Mayfield,' Wentworthville.
1883	P 4	Shellshear, Walter, M. INST. C.E., Consulting Engineer for N. S. Wales, 64 Victoria-street, Westminster, London.
1900		Simpson, R. C., Technical College, Sydney.
1910		Simpson, William Walker, 'Abbotsford,' Leichhardt-street, Waverley.
1882		Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. 'Broomage,' Kangaroo-street, Manly.
1893		Sinclair, Russell, M. I. MECH. E., Vickery's Chambers, 82 Pitt-st.
1891	P 3	Smail, J. M., M. INST. C.E., Chief Engineer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1912		Smart, Bertram James, B.Sc., Public Works Office, Lithgow.
1893	P 50	Smith, Henry G., F.C.S., Assistant Curator, Technological Museum, Sydney. *Vice-President.* (President 1913-14.)
1874	P 1	‡Smith, John McGarvie, 89 Denison-street, Woollahra.
1892	P 2	Statham, Edwyn Joseph, ASSOC. M. INST. C.E., Cumberland Heights, Parramatta.
1914		Stephens, Frederick G. N., F.R.C.S., M.B., Ch.M., 'Gleneugie,' New South Head Road, Rose Bay.
1913		Stewart, Alex. Hay, B.E., Metallurgist, Technical College, Sydney.
1900		Stewart, J. Douglas, B.V.Sc., M.R.C.V.S., Professor of Veterinary Science in the University of Sydney; 'Berelle,' Homebush Road, Strathfield.
1903		Stoddart, Rev. A. G., The Rectory, Manly.
1909		Stokes, Edward Sutherland, M.A. *Syd.*, F.R.C.P. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street. Principal Medical Officer, Second Military District.
1883	P 4	Stuart, Sir Thomas P. Anderson, M.D., Ch.M., LL.D. *Edin.*, D.Sc., Professor of Physiology in the University of Sydney; p.r. 'Lincluden,' Fairfax Road, Double Bay. (President 1893-4, 1906-07.)
1901	P 7	Süssmilch, C. A., F.G.S., Technical College, Newcastle, N.S.W.
1912		Swain, E. H. F., District Forester, Narrabri.
1906		Taylor, The Hon. Sir Allen, M.L.C., A.M.P. Society, Pitt-street.
1915	P 1	Taylor, Harold B., B.Sc., 'Ronsahl,' Moruben Road, Mosman.
1906		Taylor, Horace, Registrar, Dental Board, 7 Richmond Terrace, Domain,
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1893		‡Taylor, James, B.Sc., A.R.S.M. 'Cartref,' Brierly-st., Mosman.
1899		Teece, R., F.I.A., F.F.A., General Manager and Actuary, A.M.P. Society, 87 Pitt-street.
1861	P 19	Tebbutt, John, F.R.A.S., Private Observatory, The Peninsula, Windsor, New South Wales.
1878		Thomas, F. J., 'Lovat,' Nelson-street, Woollahra.
1879		Thomson, The Hon. Dugald, Carrabella-st., North Sydney.
1913		Thompson, Joseph, M.A., LL.B., Vickery's Chambers, 82 Pitt-street, Sydney.

Elected

1913 Tietkens, William Harry, 'Upna.' Eastwood.
1879 Trebeck, P. C., 12 O'Connell-street.
1900 Turner, Basil W., A.R.S.M., F.C.S., Victoria Chambers, 83 Pitt-st.

1913 Ullrich, Richard Emil, Accountant, 43 Bond-street, Mosman.

Vause, Arthur John, M.B., C.M. *Edin.*, 'Bay View House,' Tempe.
1883 Vicars, James, M.E., Memb. Intern. Assoc. Testing Materials;
1890 Memb. B. S. Guild; Challis House, Martin Place.
Vickery, George B., 78 Pitt-street.
1892 P 3 Vonwiller, Oscar U., B.Sc., Assistant Professor of Physics in
1903 the University of Sydney.

Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1879 ‡Walker, The Hon. J. T., F.R.C.I., Fellow of Institute of Bankers
1899 *Eng.*, 'Wallaroy,' Edgecliffe Road, Woollahra.
Walker, Charles, 'Lynwood,' Terry Road, Ryde.
1910 Walker, Harold Hutchison, Major, C.M.F., 'Vermont,' Bel-
1910 more Road, Randwick.
Walkom, A. J., A.M.I.E.E., Electrical Branch, G.P.O., Sydney.
1901 P 2 Walsh, Henry Deane, B.A.I. *Dub.*, M. INST. C.E., Commissioner
1891 and Engineer-in-Chief, Harbour Trust, Circular Quay. (President 1909-10.)
1903 Walsh, Fred., J.P., Capt. C.M.F., Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, London; Patent Attorney Regd. U.S.A.; Memb. Patent Law Assoc., Washington; For. Memb. Soc. German Patent Agents, Berlin; Regd. Patent Attorn. Comm. of Aust; Memb. Patent Attorney Exam. Board Aust.; George and Wynyard-streets; p.r. 'Walsholme,' Centennial Park, Sydney.
1901 Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1913 P 4 Wardlaw, Hy. Sloane Halcro, D.Sc. *Syd.*, 87 Macpherson-street, Waverley.
1883 P 17 Warren, W. H., LL.D., WH. SC., M. INST. C.E., M. AM. SOC. C.E., Member of Council of the International Assoc. for Testing Materials, Professor of Engineering in the University of Sydney. (President 1892-93, 1902-03.)
1876 Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Parliamentary Draftsman, Attorney General's Department, Macquarie-st.
1910 Watson, James Frederick, M.B., Ch.M., Australian Club, Sydney, p.r. 'Midhurst,' Woollahra.
1910 Watt, Francis Langston, F.I.C., A.R.C.S., 10 Northcote Chambers, off 16½ Pitt-street, City.
1911 Watt, R. D., M.A., B.Sc., Professor of Agriculture in the University of Sydney.
1915 P 4 Watts, Rev. W. Walter, 'The Manse,' Gladesville.
1910 P 1 Wearne, Richard Arthur, B.A., Principal, Technical College, Ipswich, Queensland.
1897 Webb, Frederick William, C.M.G., J.P., 'Livadia,' Manly.
1892 Webster, James Philip, ASSOC. M. INST. C.E., L.S., *New Zealand*, 'Tantallan, Middleton-street, Stanmore.

Elected		
1907		Welch, William, F.R.G.S., 'Roto-iti,' Boyle-street, Mosman.
1881		‡Wesley, W. H., London.
1892		White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1877		‡White, Rev. W. Moore, A.M., LL.D. *Dub.*
1909		White, Charles Josiah, B.Sc., Science Lecturer, Sydney Training College; p.r. 'Byrntryird,' 49 Prospect Rd. Summer H.
1908	P 1	Willis, Charles Savill, M.B., Ch.M. *Syd.*, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, D.P.H., *Lond.*, Department of Public Instruction, Bridge-street.
1901		Willmot, Thomas, J.P., Toongabbie.
1890		Wilson, James T., M.B., Ch.M. *Edin.*, F.R.S., Professor of Anatomy in the University of Sydney.
1907		Wilson, W. C., L.S., C.E., 30 and 34 Elizabeth-street, Sydney.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 6	Woolnough, Walter George, D.Sc., F.G.S., Professor of Geology in the University of Western Australia, Perth.

Honorary Members.

Limited to Twenty.

M.—Recipients of the Clarke Medal.

1914		Bateson, W. H., M.A., F.R.S., Director of the John Innes Horticultural Institution, England, The Manor House, Merton, Surrey.
1900		Crookes, Sir William, Kt., O.M., LL.D., D.Sc., F.R.S., 7 Kensington Park Gardens, London W.
1905		Fischer, Emil, Professor of Chemistry in the University of Berlin.
1911		Hemsley, W. Botting, LL.D. (*Aberdeen*), F.R.S., F.L.S., V.M.H., Formerly Keeper of the Herbarium, Royal Gardens, Kew; Korresp. Mitgl. der Deutschen Bot. Gesellschaft; Hon. Memb. Sociedad Mexicana de Historia Natural; New Zealand Institute; Roy. Hort. Soc. London; 24 Southfield Gardens, Strawberry Hill, Middlesex.
1914		Hill, J. P., D.Sc., F.R.S., Professor of Zoology, University College, London.
1901		Judd, J.W., C.B., LL.D., F.R.S., F.G.S., Formerly Professor of Geology, Royal College of Science, London; 30 Cumberland Road, Kew, England.
1908		Kennedy, Sir Alex. B. W., Kt., LL.D., D. ENG., F.R.S., Emeritus Professor of Engineering in University College, London, 17 Victoria-street, Westminster, London S.W.
1908	P 57	*Liversidge, Archibald, M.A., LL.D., F.R.S., Emeritus Professor of Chemistry in the University of Sydney, 'Fieldhead,' George Road, Coombe Warren, Kingston, Surrey. (President 1889-99, 1900-01.)
1915		Maitland, Andrew Gibb, F.G.S., Government Geologist of Western Australia.
1912		Martin, C. J., D.Sc., F.R.S., Director of the Lister Institute of Preventive Medicine, Chelsea Gardens, Chelsea Bridge Road, London.

Elected		
1905		Oliver, Daniel, LL.D., F.R.S., Emeritus Professor of Botany in University College, London.
1894		Spencer, W. Baldwin, C.M.G., M.A., D.Sc., F.R.S., Professor of Biology in the University of Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., LL.D., Sc.D., F.R.S., The Ferns, Witcombe, Gloucester, England.
1915		Thomson, Sir J. J., O.M., D.Sc., F.R.S., Nobel Laureate, Cavendish Professor of Experimental Physics in the University Cambridge.
1908		Turner, Sir William, K.C.B., M.B., D.C.L., LL.D., Sc.D., F.R.C.S. *Edin.*, F.R.S., Principal and Emeritus Professor of the University of Edinburgh, 6 Eton Terrace, Edinburgh, Scotland.

* Retains the rights of ordinary membership. Elected 1872.

Obituary 1915-16.

Honorary Members.

1901	Judd, Prof. J. W.
1908	Turner, Sir William.

Clarke Memorial Medallist.

1902	Bailey, F. Manson.

Ordinary Members.

1903	Bruck, L.
1873	Du Faur, E.
1877	Fairfax, E. R.
1876	George, W. R.
1887	Hargrave, Lawrence.
1876	Hirst, G. D.
1877	Mullens, Josiah.
1896	Thompson, Lieutenant-Colonel, A. J. Onslow.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The Revd. W. B. CLARKE, M.A., F.R.S., F.G.S., etc.,

Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia. The prefix * indicates the decease of the recipient.

Awarded

1878 *Professor Sir Richard Owen. K.C.B., F.R.S.

1879 *George Bentham, C.M.G., F.R.S.

1880 *Professor Thos. Huxley, F.R.S.

1881 *Professor F. M'Coy, F.R.S., F.G.S.

1882 *Professor James Dwight Dana, LL.D.

Awarded.

1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S.

1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.

1885 *Sir Joseph Dalton Hooker, O.M., G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.

1886 *Professor L. G. De Koninck, M.D., University of Liège.

1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.

1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.

1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.

1890 *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.

1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.

1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., LL.D., Sc. D., F.R.S., F.L.S., late Director, Royal Gardens, Kew.

1893 *Professor Ralph Tate, F.L.S., F.G.S.

1895 Robert Logan Jack, F.G.S., F.R.G.S., late Government Geologist, Brisbane, Queensland.

1895 Robert Etheridge, Junr., Curator of the Australian Museum, Sydney

1896 *The Hon. Augustus Charles Gregory, C.M.G., F.R.G.S.

1900 *Sir John Murray, K.C.B., LL.D., Sc. D., F.R.S.

1901 *Edward John Eyre.

1902 *F. Manson Bailey, C.M.G.. F.L.S.

1903 *Alfred William Howitt, D.Sc., F.G.S.

1907 Walter Howchin, F.G.S., University of Adelaide.

1909 Dr. Walter E. Roth, B.A., Pomeroon River, British Guiana, South America.

1912 W. H. Twelvetrees, F.G.S., Government Geologist. Launceston, Tasmania.

1914 A. Smith Woodward, LL.D., F.R.S., Keeper of Geology, British Museum (Natural History) London.

1915 Professor W. A. Haswell, M.A., D.Sc., F.R.S., The University, Sydney,

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AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

1882 John Fraser, B.A., West Maitland, for paper entitled 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong, for paper entitled 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper entitled 'Water supply in the Interior of New South Wales.'

Awarded.

1886 S. H. Cox, F.G.S., F.C.S., Sydney, for paper entitled 'The Tin deposits of New South Wales.'

1887 Jonathan Seaver, F.G.S., Sydney, for paper entitled 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.'

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper entitled 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for paper entitled 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.'

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper entitled 'The Australian Aborigines.'

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper entitled 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper entitled 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper entitled the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper entitled 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, D.Sc., M.B., F.R.S., Sydney, for paper entitled 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper entitled 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS.

By Charles Hedley.

With Plates I - VII.

[*Delivered to the Royal Society of N. S. Wales, May 5, 1915.*]

On this, our ninety-fourth anniversary, we assemble under a world wide shadow. For this year the minds of men have been turned from the quiet paths of industry and of science to the tremendous struggle of European conflict. So in this serious time we refrain from such pleasure as our annual dinner or conversazione, but endeavour to carry on our work as usual.

Chief among the scientific events of the past year was the visit of the British Association to Australia. For some time we had looked forward to this, and had prepared for its success. Now looking back we remember it as a festival thoroughly enjoyed both by visitors and residents.

The aggregate membership of the various centres totalled 4,700, a figure considerably higher than the previous maximum of the Manchester meeting. Unfortunately the first crash of the European war coincided with the arrival of the Association. This interfered with means of travel, forced some to return to England immediately, caused a hasty revision of plans for others and made difficulties for several foreign members. The decease of the Chancellor of the University cast a gloom over the proceedings, and quenched a conversazione which had been prepared as a finale to the meeting.

Both State and Federal Governments accorded gracious welcome and granted official assistance, and such privileges as free railway passes over the whole continent.

Many lasting friendships, much educational correspondence, and many novel ideas were originated by the visit to Australia of the British Association. Probably it is not too much to say that every worker here in every branch has received a stimulus to more and better work. Even before the arrival of our guests, we benefited by preparation, by setting our house in order, by producing as handbooks, the best summaries of the fauna, flora, geology, ethnology, and social evolution of Australia that have yet appeared. Again, we benefited by the personal contact of student with student, of specialist with specialist; by advice or suggestions, even by communication of ideas too nebulous for print or paper, but which yet may be fruitful and far-reaching. Yet again benefits are to accrue to us from field work on long journeys conducted by our visitors, such as the researches on ethnology by Haddon, Rivers, Malinowski, Layard, and Brown; on geology by Davis; on echinoderm larva by Mortensen; on monotreme affinity by Watson; on the Formicidæ by Wheeler.

Several grants were made by the Association in aid of Australian research in palæobotany, marsupial anatomy, the biology of the Abrolhos Islands and Antarctic oceanography.

The aim of our existence, the production and distribution of knowledge, has been pursued diligently. Our annual volume may be regarded with satisfaction. In 519 pages and 12 plates the Journal includes 29 contributions from 24 authors. These range over botany, zoology, geology, chemistry, mechanics, mathematics and statistics. Indeed so wide a field has not, I think been covered in any previous year.

Under the care of Professor Pollock considerable progress has been made in the rearrangement of the library. During the year location lists have been completed of the

whole of the periodical literature in the possession of the Society. The current numbers of journals are now arranged on the shelves round the basement room according to subjects, so that all the periodicals regularly received dealing with any subject may be seen at a glance. Shelving to the full accommodation of basement room has been erected at a cost of £210 17s. 6d. This additional shelving, so long and urgently required, will allow the considerable number of foreign periodicals, hiterto stored, to be displayed and made available for ready reference. While making this addition to the library, it is considered advisable to rearrange the whole contents according to subject matters instead of according to country of origin as heretofore. On the completion of this rearrangement, a catalogue will be available, giving the location of all the journals in the library. In the past year, 914 volumes have been bound.

The tercentenary of Napier of Merchiston was commemorated by a lecture, on the discovery of logarithms, delivered by Professor H. S. Carslaw. This interesting discourse was enjoyed by a large audience, including His Excellency the State Governor. The kindness of Professor Carslaw enabled us to participate in a world-wide celebration in honour of this British genius.

Popular Science lectures were given in our rooms to audiences of about a hundred on the following dates, June 18th, "The Ore Deposits of Australia and their origin," by Mr. C. A. Süssmilch; July 16th, "Comets," by Professor Cooke; and October 15th, "The Milk Supply of a Great City," by Professor Chapman. To these gentlemen, the Society is indebted for intellectual profit and pleasure.

Next year we shall miss from the Council table two trusty and experienced members, both Ex-Presidents, Mr. F. B. Guthrie and Mr. W. M. Hamlet, who have intimated that other engagements will not allow them to attend. We offer

them grateful thanks for the care with which they have conducted our business for so many years.

Finally it is an agreeable duty to acknowledge how much the President and the Society owe to their honorary officers Professor Pollock, Mr. Cambage, and Professor Chapman. The successful management of our affairs has been at the cost of much leisure time sacrificed by these gentlemen.

This year our Clarke Memorial Medal was awarded to Professor W. A. Haswell, in appreciation of his biological researches. For thirty-six years he has continuously published important papers on the Australian fauna, usually selecting for elucidation those groups which other writers had avoided as difficult or unattractive. To such industry is happily united breadth of grasp, lucidity and finish. The text-book of zoology which he produced in conjunction with Professor Parker, is used and valued as much in Europe and America as in Australasia. But Professor Haswell has given us men as well as memoirs, workers as well as work; from his laboratory have come Professor J. P. Hill of London, Professor Goddard of Cape Town, Professor Flynn of Hobart, Dr. Harvey Johnston of Brisbane, Dr. Stephen Johnston and others.

We have the pleasure of congratulating Professor David on yet another honour, another upward step in his distinguished career. This session, the Geological Society of London awarded to him the Wollaston medal, the highest honour it has to bestow. The list of the medallists begins in 1831 with William Smith the "Father" of Geology, continues with such famous names as Agassiz, Owen, Darwin, Lyell, Dana, Huxley, Geikie, Suess, Woodward, and now terminates with that of Professor T. W. E. David.

It is perhaps hardly a coincidence that this award was immediately preceded by the publication of a magnificent volume by Professor David and Mr. Priestly on the "Geology

of the British Antarctic Expedition under the command of Sir H. E. Shackleton." This standard work on the climate and structure of the Polar Continent is profusely illustrated by 150 maps, photographs and sketches. It treats of the greatest glaciers of the globe, the meteorological conditions under which they form and the phenomena to which they give rise. Then it continues to deal with the preglacial formations, their structure, history and relation to the outside world.

The Linnean Society of London have recently expressed their appreciation of Mr. J. H. Maiden's contributions to Australian Botany by awarding to him the Linnean Gold Medal. This coveted distinction is allotted annually alternately to a Botanist and then to a Zoologist. The medal has not previously come to the southern hemisphere, and the honour bestowed on our friend and colleague is a pride to the whole Society.

It was with satisfaction that we read the announcement that the David Syme Prize for scientific research had again been awarded to a member of this Society, and based partly on the investigations published in our journal. This year it was allotted to Mr. E. C. Andrews in recognition of his work on economic geology, and on the physiography of Eastern Australia.

Necrology.

A sketch of the careers of those comrades of whose company death has deprived us since our last anniversary here follows:—

Mr. Henry Joseph Brown was the son of Mr. Octavius Brown, an old time Sydney lawyer. Establishing in Newcastle the firm of Brown and Mitchell, he gained, throughout the State the reputation of a sound and capable practitioner. For half a century he acted as legal adviser to the Australian Agricultural Company and other impor-

tant corporations. Educational matters, particularly interested him, and for thirty years he successfully presided over the Newcastle School of Arts. Having been elected in 1876, he was one of our senior members, but a constant residence in Newcastle rarely allowed him an opportunity of attending the meetings. After a brief illness he expired in his eightieth year, on August 12th, 1914.

Mr. THOMAS JAMES BUSH, M. Inst. C.E., was born in London. Early in life he entered the service of the Gas-light and Coke Co. of Beckton, England. Gaining here a reputation as an authority on gas matters, he was invited to assume the management of the engineering department of the Australian Gas-light Co. of Sydney, in 1878. He was elected a member of this Society in 1880. Retiring from business last year he returned to London, where he died at the age of 67, on September 23rd, 1914.

Mr. MICHAEL CANTY was, for many years secretary and registrar of the Department of Taxation. He was born on August 22nd, 1850, and educated at the Sydney Grammar School. In 1871 he entered the Lands Department, and becoming a proficient draftsman, was appointed to various positions in succession in the Roads, Charting, and Compiling Departments. When thirty-seven years of age he withdrew from the Public Service to embark in commercial pursuits. But on the introduction of the Land and Income Tax of 1895, Mr. Canty was invited to organise the new machinery. In 1899, he was appointed Registrar of the Department, a post that he occupied till he finally retired from the Service in April 1914. He was elected a member of this Society during the session of 1900. At the age of 64 he died on September 29th, 1914, regretted by a large circle of friends, to whom his genial disposition had long endeared him.

Mr. ECCLESTON FREDERIC DU FAUR, F.R.G.S., was born in London, in 1832, and educated at Harrow. He arrived in Victoria when he was twenty-one, and after some years of travel settled down in Sydney in 1863, where he was engaged as a draftsman in the Lands Office, becoming Chief Draftsman of the Department of Survey of Runs and Occupation of Lands. In 1881 he retired from the Government service and was engaged in business pursuits for the following twenty years. Turning his attention to the progress of geography, he organised in 1874 an expedition to ascertain the fate of Leichhardt, and another in 1877 to despatch Wilfrid Powell on a voyage of discovery to New Britain. He assembled in 1883 a local Geographical Society of which he was the first chairman, and which in 1885 arranged a party under Captain Everill to explore the Fly River. This State owes much to the keen interest which Mr. Du Faur took in Art. For he helped to form an Academy of Art in 1871, and when this was succeeded by the National Art Gallery, he became first the honorary secretary and treasurer, and finally president. The high position now reached by the Gallery is due largely to his energy, administrative ability and taste. Mr. Du Faur joined this Society in 1873. He contributed two papers to our periodical, viz., "Re notable hailstorm of 17 November 1896 in parts of Parish of Gordon," (Journ. XXX, 1897, pp. 361–368, pl. xxiii); "The effect of Polar Ice on the weather," (Journ. XLI, 1907, pp. 176–189, plates xiii–xvi. He died in his eighty-fourth year, on 24th April, 1915, leaving a family of one daughter and two sons.

Science lost a staunch friend, and the State one of her most worthy citizens when the Hon. Sir HENRY NORMAND MACLAURIN died. He was born on September 10th, 1835, at Kilconguhar in Fife, Scotland, where his father James MacLaurin was a school master. As a boy he showed

remarkable ability, for at the early age of 15 he won an open scholarship at St. Andrews. Here he gained first in every subject, and left as a Master of Arts at the age of 19. In 1857 he received a degree in medicine from the Edinburgh University. Entering the Royal Navy, he served as a medical officer for thirteen years. Then he established himself in practice in Sydney in 1871, where he married a a daughter of Dr. Charles Nathan. He joined the Royal Society in 1876, but his many public duties allowed him little time to take part in our affairs. For several years he was associated, first as a member, then as President, of the Board of Health, where he conducted a successful crusade against typhoid and plague. His administrative talent ranged over a wide sphere. In 1889, he was appointed to the Legislative Council, and in 1893 attained Cabinet rank as Vice-President of the Executive Council. It is said that the measures which ameliorated the financial crisis of that year were initiated by him. He took a vigorous part in the discussions, especially on the financial aspect, that preceded Australian Federation. The service of higher education had early enlisted his forceful personality; in 1883 he was elected to the Senate of the University, became Vice-Chancellor in 1887, and was appointed Chancellor in 1895. To the control of University work he brought an uncommon combination of talents. For the material welfare of the institution was advanced by his shrewd foresight and financial ability, while the intellectual aspect was cherished by the sympathetic guidance of the scholar. A man of kindly disposition, a brilliant scholar, and a master of finance, his abilities were ever employed for the advancement of the public good. Rich in honour and dignity, in years and in esteem, he passed away in his seventy-ninth year on August 23rd, 1914.

Mr. William John Clunies Ross, B.Sc., F.G.S., was related to the famous pioneer of Cocos Keeling Island, of the same

name. He was born in London in 1850, and made his first visit to Australia in 1864. Returning to England he completed his education at King's College, London, where he was Science Scholar and Associate. In 1884 he was appointed to the charge of the Technical College Bathurst. He found the institution meanly lodged in a basement in the School of Arts, and he left it in possession of a fine building in William Street, where there was also an excellent Museum. This transformation was due to his guiding care, energy and enthusiasm. Among his students and fellow citizens he strove with a success to foster a love of science. Eleven years ago he was transferred to the capital and placed in charge of the chemical and mineralogical departments of the Technical College. For these classes he wrote various school books. He joined our Society as soon as he became a resident of Sydney, and from 1904 he was a regular attendant and frequent speaker at our meetings. A wide range of information and fluent expression enabled him to offer interesting comment to most scientific discussions. Also he contributed three papers to our Journal:—"The Geology of Limekilns, Bathurst District," Vol. XXVIII, 1894, pp. 289 – 301; "Notes on the Basalts of Bathurst and the neighbouring districts," Vol. XXXI, 1898, pp. 296 – 213; "Experiments with Silicate of Soda and observations thereon," Vol. XLIV, 1910, pp. 583 – 592. He was also author of a paper on the flora of Bathurst,[1] considered in its ecological aspect, a pioneer study in the relation of Australian plants to rocks. On November 7th, 1914, he died, as he was about to retire on a pension after thirty years service. He leaves a widow and four sons.

Among the brave men who fell on 24th April, 1915, while storming Turkish entrenchments near the Dardanelles, was

[1] Ross, Rep. Austr. Assoc. Adv. Sci., 1898, pp. 467 – 481.

Lieut-Colonel ASTLEY JOHN ONSLOW THOMPSON, V.D. He was related to a well known family of Australian pioneers, and was born at Tenby, Wales, on 3rd January, 1865, being the eldest son of Astley Thompson of Glyn Abbey, Carmarthenshire, High Sheriff of the County, and Udea Thompson, *nee* Onslow. He received his education at Rugby, and came to Australia when eighteen years of age. At first he was engaged in the Harbours and Rivers Department, but withdrew from the Government service to follow pastoral work. In 1887 he returned to his native land, and studied dairying in England and irrigation in Northern Italy. He returned to Australia in 1889, and was appointed manager of "Camden Park," which position he filled with conspicuous ability up to the time he left on active service last year. Military matters had always interested him, so that in 1892, with Colonel J. W. Macarthur Onslow he raised the Camden Squadron of the New South Wales Mounted Rifles (now known as Light Horse) and subsequently rose to the command of the regiment. In 1897 he acted as Adjutant and Paymaster to the detachment of this regiment which went to England to take part in the Diamond Jubilee of Queen Victoria, and while there went through a course of training with the Scots Greys at Hounslow and Carabiniers at Aldershot. At the time of the Boer War he did much useful work in the training and organising of one of the contingents that was formed for active service in South Africa. His business capacity was recognised by his election to the Board of the Commercial Banking Company of Sydney Ltd., Colonial Sugar Refining Company, and several others. He was president of the Camden Agricultural Society for several years past, and a generous giver to all charitable objects. Our late member, who was in his fifty-first year, joined us in 1896, but as a country member seldom attended the meetings.

Also I shall refer to two gentlemen, who, though not in association with us at the time of their decease, were formerly valued members of the Society.

Mr. Richard Helms was born at Altona, Germany, on December 12th, 1842. He was one of a type, now vanishing, of keen, self-taught, field-naturalists, of which George Masters, John Brazier, and William Petterd were exponents and who did such excellent work in the past generation. The whole range of natural science attracted him; in botany, zoology, geology, and ethnology, he was equally interested and of these his knowledge was encyclopædic. In the field he was an expert hunter, handy with tricks and traps and having the wisdom of a savage as to where a bird would nest or a beetle burrow. Quite careless of hardships, such as cold, hunger, or fatigue, he would explore alone in the roughest country. He arrived in Australia in 1858, and assisted his cousin in a cigar business in Melbourne. About 1862 he crossed over to New Zealand and spent some time in Dunedin. After another visit to Melbourne he commenced practice in 1876 as a dentist in Nelson, New Zealand. During the late seventies and early eighties he resided at Greymouth; in 1879 he married and engaged in business as a watch-maker. Here he made his first contributions to scientific literature.[1] Becoming interested in the coleoptera, he formed a large collection. Then he added conchology to his studies and maintained an active correspondence on the subject with Capt. F. W. Hutton. The west coast of the South Island was then zoologically unknown, and as a pioneer Helms was able to add largely to the number of species recorded from New Zealand. His industry may be illustrated by some of the species discovered by, and named after him. Fereday named for him a new butterfly *Dodonidia helmsi*. Dr.

[1] Helms, New Zealand Journ. of Science, i, 1883, pp. 466, 516.

David Sharp[1] from 1882 to 1886, in recognition of his researches named the following:—*Lissotes helmsi*, *Cicindela helmsi*, *Anchemenus helmsi*, *Steropus helmsi*, *Zolus helmsi*, *Tomus helmsi*, *Adelopus helmsi*, *Dasytes helmsi*, *Pycnomerus helmsi*, *Periatrum helmsi*, *Somatidia helmsi*, *Anagotus helmsi*, *Icmalius helmsi*, and *Pentarthrum helmsianum*. Among many novelties in land shells furnished from Greymouth to Capt. Hutton, there was included *Zonites helmsi*.[2] In 1894 a marine shell from New Zealand was called *Acmaea helmsi* by Mr. E. A. Smith, and in 1915, the writer named an Australian shell *Erycina helmsi*.

In November 1888 he came to Sydney and entered the service of the Australian Museum. Early in 1889 he was despatched on a collecting excursion to Mount Kosciusko, an interesting account of which has been published.[3] Here he gathered a large series of the hitherto unknown alpine fauna. One discovery of especial interest was the primitive isopod *Phreatoicus australis*. Kosciusko exercised an attraction for Helms for the rest of his life, and he returned to it again in 1893, and again in 1901. He wrote an article "On the recently observed evidences of an extensive glacial action at Mount Kosciusko."[4] This evidence was subsequently doubted by Milne Curran, but was finally vindicated in an important paper in which Helms was associated with Professor David and Mr. Pittman.[5] The natives of the Monaro Highlands were described in his Anthropological Notes.[6] He summed up his knowledge of the climate, fauna and topography of the Range in a memoir "The

[1] Sharp, Trans. Entomol. Soc., 1887, p. lxxiii.

[2] Hutton, Trans. N.Z. Inst., xv, 1883, pp. 134–141; xvi, 1884, p. 161.

[3] Helms, Rec. Austr. Mus., i, 1890, pp. 11–16.

[4] Helms, Proc. Linn. Soc. N.S.W., xviii, 1894, pp. 349–364.

[5] Proc. Linn. Soc. N.S.W., xxvi, 1901, pp. 26–74,

[6] Helms, Proc. Linn. Soc. N.S.W., xx, 1896, pp. 387–408.

Australian Alps or Snowy Mountains."[1] Concluding his alpine explorations in 1889, he proceeded on a collecting tour along the Darling River. After this he relinquished the Museum service and proceeded to the Richmond River in the interest of a private syndicate. He joined the Department of Agriculture of New South Wales in November 1890 as collector, but resigned the position in April 1891, to join the Elder Exploring Expedition. As naturalist he travelled through Central Australia with this expedition, which started in May 1891, and was dissolved in June 1892. Here, as usual, he proved an expert and indefatigable collector. Among his numerous discoveries, Baron von Mueller called a new shrub *Grevillea helmsiana*, and Dr. J. Müller named a new lichen *Endocarpon helmsianum*. In describing the results of the expedition, the Rev. J. Blackburn took the occasion to name after Helms, ten new beetles of the following genera:—*Belus*, *Calycopeplus*, *Olivina*, *Tetracha*, *Thryptomene*, *Zonitis*, *Dasytes*, *Heteronyx*, *Plagianthus* and *Telaurina*. An article on the Ethnology of the expedition was written by Helms.[2]

Returning to Sydney, he was re-engaged by the Department of Agriculture, as Assistant Entomologist. He resigned this position in March 1896 to accept an appointment as Fruit Inspector in Western Australia. He finally returned to Sydney in January, 1900, as Experimentalist to the Department of Agriculture, the last occupation of this versatile man. Here he was valued by Mr. Guthrie as "one of the keenest and most original of workers." Helms joined this Society in 1900, but relinquished his membership in 1910. In conjunction with Mr. F. B. Guthrie, he wrote three papers in our Journal on "Pot Experiments to determine the limit of endurance of different farm crops for

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[1] Helms, Journ. Roy. Geograph. Soc. N.S.W., vi, pp. 75 - 96.

[2] Helms, Trans. Roy. Soc. S.A., xvi, 1896, pp. 238 - 332.

certain injurious substances."[1] To the Agricultural Gazette of N. S. Wales, Vols. IV to XIX, he contributed fourteen papers, dealing with apiculture, bacteriology, wheat, and manure. After he was superannuated from the Government Service he busied himself with naming, arranging and expanding the large natural history collections he had formed. Returning from a voyage to the Solomons, the sudden change of climate brought on a cold to which he succumbed in his seventy-second year on July 17th, 1914. He left a family of two daughters.

Mr. LESLIE A. B. WADE, Assoc. M. Inst. C.E., adopted the profession of his father, Mr. W. B. Wade, and entered the service of the Government as an engineer in 1880. For some time he was engaged in drainage works, but on the formation of an irrigation branch he joined it, and ultimately rose to its control, as Commissioner for Water Conservation and Irrigation. Amongst other works he designed the Cataract Dam, the Burrenjuck Dam, and the Murrumbidgee irrigation scheme. His work in this direction was very sound, and will benefit a future large agricultural population. He joined our Society in 1898, contributing a paper in 1903, "A Review of Water Conservation in New South Wales," and retired in 1909. On January 13th, 1915, he died rather suddenly, at the age of 50 years, leaving a widow and four daughters.

The loss of the Fisheries Investigation vessel 'Endeavour' with all hands, about the end of last year, off Macquarie Island, was a scientific, as well as a social disaster. For several years Mr. H. C. DANNEVIG, Director of Fisheries, equipped with every modern requisite for oceanographic research had been engaged in examining the coasts of most Australian States. His collections were remitted to the

[3] This Journal, xxxvi, 1902, pp. 191 – 200; *Id.* xxxvii, 1903, pp. 165 - 171; *Id.* xxxviii, 1904, pp. 390 - 401.

Australian Museum for study, and a couple of volumes of valuable zoological reports on them have been already issued by the Federal Government. But important reports which Mr. Dannevig was preparing on the physical conditions of the continental shelf have unfortunately disappeared with him and his vessel. He published in our forty-first volume an article "On Some Peculiarities in Our Coastal Winds and Their Influence upon the Abundance of Fish in Inshore Waters."

For the scientific portion of the address the following subject is chosen for discussion because it has been, hitherto, but little cultivated.

An Ecological Sketch of the Sydney Beaches.

SYNOPSIS:

INTRODUCTION.

ENVIRONMENT—Ground,
Temperature,
Salinity,
Tides.

COMPARISON OF LOCAL AND FOREIGN FAUNA.

CHANGES OF CLIMATE AND TIME.

CHANGES BY EPIDEMICS AND ACCIDENTS.

TRANSITION FROM MARINE TO TERRESTRIAL.

TYPES OF BEACHES—Shingle beach,
Ocean sand beach,
Estuarine beach,
Ocean reef beach.

Introduction.

Marine ecology, that is the relation of marine organisms to their surroundings and to one another, is undeveloped in comparison with terrestrial ecology, because our knowledge of the life history and physiology on which such studies depend is deficient. Yet exceptional advantages are offered to the Sydney naturalist, because a variety of stations ranging from fresh water to salt, from rock to

mud, and from shelter to exposure are here concentrated in an area conveniently small for comparative study. The shore line of the Port Jackson "ria" winds by so many creeks and coves that from Head to Head it extends for one hundred and eighty-three miles.

The intertidal zone around Sydney may be grouped, ecologically, into three divisions, decided by the situation of the fauna and flora; viz., (1), the sandy beach, (2), the muddy estuary, and (3), the rocky reef. Each of these areas maintains a marine community which by internal relation and external distinction rank with such a terrestrial society as may dwell in a forest, a marsh or a meadow. These three associations of beach life are repeated, with slight local modifications, over such wide geographic space, perhaps even right round the world, that we may regard them as having persisted with little change for a long geologic period.

As the plants of an English forest may be more closely related to those of an American forest in another hemisphere than to those of a fen in a neighbouring county, so the marine fauna of the Parramatta River is more akin to another estuarine fauna, even if it be one or two thousand miles away, than to the rock fauna of the nearby Bondi Beach. It is as if two cities stood side by side, yet remained foreign to each other in race, language, and customs.

Though the ocean does not present to migration such barriers,—mountains, deserts or forests,—as does the land, marine species rarely, but genera frequently, attain a world wide range.[1] The sea being more monotonous than the land would less frequently originate new types. But when it did come into existence a new marine type would spread more readily than a terrestrial one, hence the greater uniformity of marine life. In the sea as well as upon the

[1] M'Intosh, Ann. Mag. Nat. Hist. (7), xiii, 1904, p. 130.

land, the conditions of life are fixed and the range of species limited by physical environment; thus the nature of the ground, whether hard or soft, sheltered or exposed, decides whether a particular spot shall support eel-grass or kelp, cockles or limpets, but, within broad geographic limits, temperature then decides which kind of a limpet or a cockle it shall be. As Dr. F. B. Sumner wisely observes, "any investigation not based on knowledge of physical data may be dismissed as futile."[1] Records of such physical data for this neighbourhood are scanty, and it is very desirable that more information should be collected, especially as this knowledge has an important economic bearing on the study of the migrations, spawning and abundance of food fishes.

Environment.

Environment of the intertidal flora and fauna may be discussed under the following headings; (1) the nature of the floor, whether of sand or mud or rock, whether bare or draped with vegetation, (2) the temperature of the air and the water, (3) the purity of the sea, whether quite salt or mixed with fresh or muddy water, (4) the action of the tides and currents. The local disposition of beach animals follows naturally the plant formation, such as a mangrove forest, a zosteretum or a hormosiretum. So that if a beach be classified for its plant contents, it will be found arranged into natural faunal areas. The intertidal, like any other fauna, ultimately depends for food and shelter upon the vegetation.

ROCK FLOOR.

Since the "roots" or rather rhizoids of seaweeds convey no nourishment, but merely serve as anchors, it might be thought that the nature of the ground on which they grew was not a matter of importance. But actually the stones

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[1] Sumner, et al. Publ. Univ. Calif. Zool., xiv. 1914, p. 5.

of the shore exercise considerable influence on the flora and fauna that inhabit it. One geological outcrop produces a broken beach of pools and crags, another a smooth flat. Loose rocks that roll about and crush are a danger to the marine community, while large immovable boulders afford a long lease of shelter to their lodgers. The rough beach presented by limestone supports a rich fauna. Algæ are favoured by the harsh minutely pitted surface of basaltic rock, but granite worn smooth is distasteful both to plants and animals. Where the rock is friable, a storm tears off together the weed and the stone to which it has made fast. The nature of the rock also determines the quality of the sand or pebbles on the beach. Where rock is stained by infusions of iron, some molluscs which adhere to it, such as limpets or chitons, assume a dark hue to match the background.

Shale beds round Sydney are bored by *Pholas* which cannot face the gritty sandstone. But the sandstone is pierced both by the bivalve *Venerupis* and the crustacean *Sphaeroma.*[1] Cups in the sandstone are carved by the urchin *Toxocidaris* (Plate VII, fig. 11).

TEMPERATURE.

For many years records were kept of the temperature in Sydney Harbour by the Government Astronomer of New South Wales. These readings were taken only once a day at 9 a.m. from a thermometer sunk three feet below the surface at Fort Denison, an island in mid-channel.[2]

The following decennial average is based on Russell's "Monthly Record" for the period of 1881–1890, expressed in Fahrenheit.

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[1] Hedley, Rep. Aust. Assoc. Adv. Science, viii, 1901, p. 240.

[2] Russell, H. C., Meteorological Observations made at the Government Observatory.

	Mean.	Maximum.	Minimum.
January	70·9	72·3	69·1
February	71·2	72·4	70·0
March	70·5	72·1	68·7
April	68·4	70·5	66·3
May	64·6	67·0	61·8
June	60·4	62·5	57·5
July	57·0	59·3	55·8
August	57·9	59·3	56·6
September	60·2	61·5	58·9
October	63·1	64·6	61·8
November	66·4	68·2	64·5
December	70·3	71·4	66·9

Such observations, limited to a single spot, and to a single hour, present too narrow a view of the water climate. Probably they convey a better idea of the maxima than of the minima. In shallow water, and in the remoter reaches of the harbour, the temperature might be warmer in summer and colder in winter than this.

The decennial maximum 75·5 was reached on January 15th and 20th, 1887; the minimum 50·1 occurred on July 20th, 1881. The hottest days of the year happen in either December, January, February or March, and the coldest days either in July or August. February has the highest mean temperature and July the lowest. It is noticeable that the warmest months are the most equable, the temperature sometimes oscillating only from one to two degrees, while the coldest months are the most variable. Compared with the range of temperatures noted at biological stations abroad, the Sydney records are singularly level. Thus at Woods Hole in the western Atlantic the temperature ranges from below freezing to 70°, and in the Bay of San Francisco from 42° to 69°.[1] Off Plymouth, England, some

[1] Sumner, Bull. U.S. Fisheries, xxxi, 1913, p. 436, Id. Univ. Calif. Zool. Publ., xiv, 1914, p. 99.

incomplete sea surface temperatures range from 44·1° to 58·9°.[1]

The temperature of the water both in Sydney Harbour and along the coast is altogether governed by the Notonectian Current, the Gulf Stream of Australia.[2] In midwinter this is blown off shore and the temperature normal to the latitude then prevails. But in midsummer the Notonectian running at its highest volume, speed and temperature, hugs the land and overflows the harbour water. Thus a warmth is attained, independent of the locality, which may temporarily establish tropical conditions. If continental land were to arise once more between New Zealand and New Guinea, then this current would be shut off from the Australian coast, and both our climate and our fauna would change at once.

The critical temperature, that which determines life or death for plants and animals, is likely here to be the minimum. A low spring tide of a winter's night must be the trial for existence of all intertidal life.

SALINITY.

Scarcely any observations have been made on the salinity of the sea water in the neighbourhood of Sydney. From the irregularity of the rainfall, the absence of large streams flowing into the harbour, and the clearness of the water to the eye, it is apparent that the salinity is unusually high for a coast station. At the upper ends of the inlets the water is of course more fresh and muddy than at the entrance.

Mr. T. W. Fowler has published some observations on the density of sea water off the coast of New South Wales.[3]

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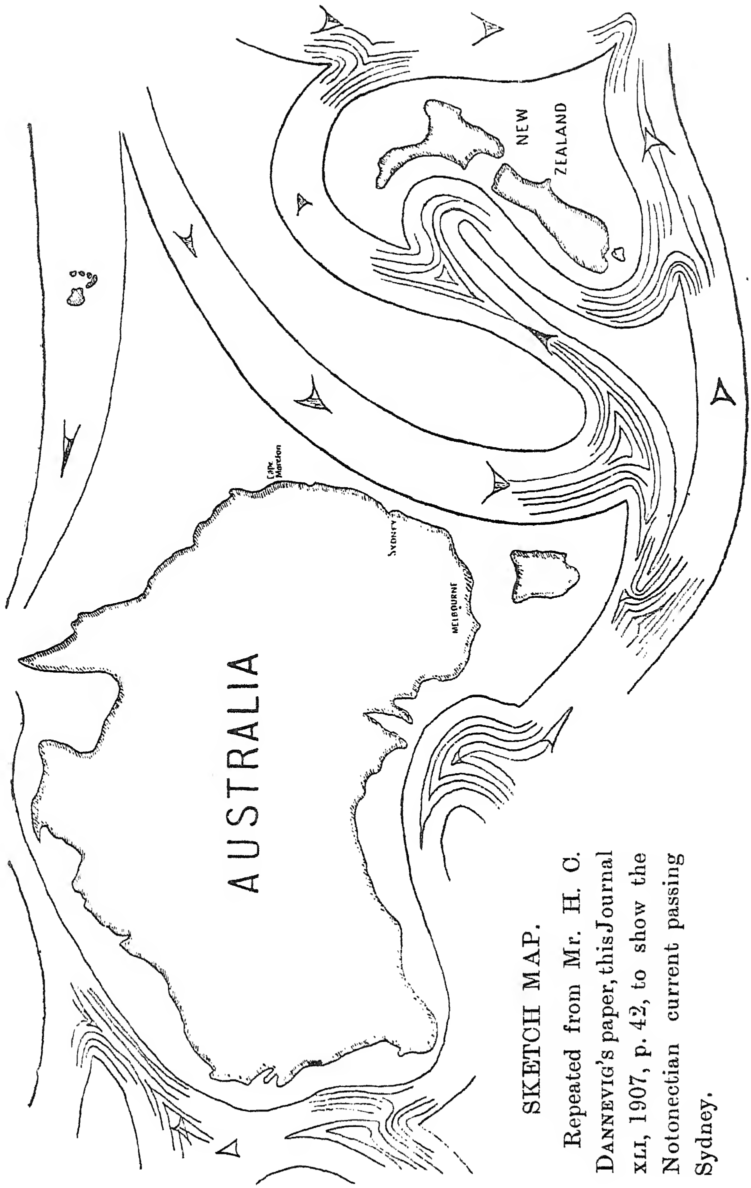
[1] Journ. Mar. Biol. Assoc., ii, 1892, p. 276.

[2] Hedley, Proc. Linn. Soc. N. S. Wales, xxxv, 1910, p. 9.

[3] Fowler, Rep. Aust. Assoc. Adv. Science, 1898, p. 695.



SKETCH MAP.

Repeated from Mr. H. C. Dannevig's paper, this Journal xli, 1907, p. 42, to show the Notonectian current passing Sydney.

As a contribution to this subject, Dr. H. G. Chapman has kindly handed to me the following observations:—

"The same constituents are found in all samples of sea water, and practically they are in the same relative proportions everywhere. In other words, when the quantities of the salts in any sea water are expressed in percentages of total solids similar figures are obtained for each constituent of the sea water. The total amount of solid matter, however, is subject to much variation.

"The chemical composition of ocean water off Sydney does not differ much from that of ocean water generally. A sample taken off Coogee at a temperature of 22° C. had a specific gravity $\frac{15 \cdot 56^\circ}{4^\circ}$ of 1·0261. Its solid contents were calculated at 35·2 gm. per kilo. of sea water. The total halogens estimated as 19·475 gm. per kilo. and the sulphates estimated as SO_4 were found to be 2·76 gm. per kilo.[1]

"An analysis of a sample taken one foot below the surface about 50 metres from the shore at Balmoral Beach, Middle Harbour, Port Jackson at half tide on the ebb gave the following data:—

Temperature ...	25° C.
Specific gravity $\frac{15 \cdot 5^\circ}{4^\circ}$	1025.
Freezing point ...	− 1·9 C.
Total solids... ...	34·7 gm. per kilo sea water.
Halogens as chlorides	19·25 gm. per kilo. sea water.
Sulphates as SO_4 ...	2·62 gm. per kilo. sea water.

"When the sea water stands in a rocky pool on the shore, even if awash with the tide, concentration of the salts occurs. From a pool on the eastern shore of Bradley's Head in which many living shells, sponges, sea weeds, etc. were present, a sample of water was obtained, yielding the following data:—

Temperature ...	20° C.
Specific gravity $\frac{15 \cdot 5^\circ}{4^\circ}$	1027·3

[1] These figures are calculated from a paper by Mr. C. J. White, Journ. Roy. Soc. N.S. Wales, xli, p. 55, 1907.

Freezing point	...	$-2{\cdot}335$ C.
Total solids ...	...	43·8 gm. per kilo. sea water.
Halogens as chlorides		24·29 gm. per kilo. sea water.
Sulphates as SO_4	...	3·59 gm. per kilo. sea water.

The ratio of halogens to sulphates which is close to that found in all samples of sea water is evidence that this water is sea water concentrated by evaporation."

TIDES.

On the open coast the tides are regular, and of considerable amplitude. A stream of flood tide runs northwards, and the ebb southwards. At the entrance to the harbour it is high water at new and full moon at 8·15 when the spring tides rise about six feet. Further up the harbour at Circular Quay, the tides are twenty-five minutes later, and about ten inches lower. The highest tide recorded in the harbour was that of January 5th, 1912, which amounted to six feet nine and a quarter inches.

A curious phenomenon is the difference between the night and the day tides in summer and winter. In the winter the night tides are highest but in summer those of the day. After the equinoxes the difference gradually increases till, in July and January, it may amount to as much as two feet. The sedentary intertidal organisms are exposed to both extremes of air temperature, cold in winter and heat in summer. The on and off shore winds may magnify or diminish any particular tide.

Comparison of Local and Foreign Fauna.

Both in species and in individuals, the local fauna is extremely rich, probably more so than in any marine area in the temperate zone of the northern hemisphere. Rocks are turfed with ascidians for yards without exposing an inch of stone. In other places oysters sheath the rocks with a continuous crust. There is a crab that marches in regiments. Even above ordinary tide level a small gre-

garious periwinkle packs together in scores. Once a collector picked up a derelict bottle among the rocks at Watson's Bay. Washing out its contents with care, he found this chance handful to contain a hundred and fifty-five different species of shells.[1]

In Europe or the United States where the marine fauna is comparatively scanty and where there are a host of specialists, it has been a heavy task to catalogue the fauna. Here where the harvest is greater and the labourers fewer it is of course more difficult still. Work in this direction has, however, been proceeding steadily of late years.

There is no recent summary, but a census of the marine invertebrate fauna of Port Jackson prepared by Mr. T. Whitelegge, twenty-five years ago, enumerated 2,136 species.[2]

No other similar area in the southern hemisphere has yet been catalogued. From a larger and infinitely better studied district, the Irish Sea, Prof. Herdman reports 1681 marine invertebrates. From the neighbourhood of Trieste in the Adriatic, Dr. Graeffe gives 1,268 species, and Dr. Sumner repeats exactly the same total for Woods Hole, U.S.A.[3] From an excellent summary of the fauna of the Firth of Forth, lately presented by Mr. William Evans,[4] it appears that 1,213 marine invertebrates have been identified from this area. Lest we, in this young country, should be discouraged at the slow progress of our science, we may observe the confession of Mr. Evans that scarcely more than half his local fauna is yet catalogued, after two centuries of research by one of the most intellectual cities of the world.

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[1] Henn and Brazier, Proc. Linn. Soc. N.S. Wales, (2) ix, 1894, p. 165.
[2] Whitelegge, this Journal, xxiii, 1889, pp. 163–296.
[3] Sumner, *op. cit.*, 1913, p. 88.
[4] Royal Physical Society of Edinburgh, xvii, 1909, pp. 1—64d.

The composition of these northern faunæ appears to differ somewhat from ours. There the crustacea are the most populous group, but here it is the mollusca. The sponges form a larger proportion of the Australian than of the Atlantic fauna. In the Irish Sea the Echinodermata are but a fiftieth of the total, here they are an eighteenth. But the Protozoa of the Irish Sea contribute one-seventh of its invertebrate fauna while our list represents them only as one-fifteenth. So it may be that the discrepancy between north and south lies in the early recognition here of the large conspicuous forms and the late (or rather future) detection of the smaller and inconspicuous species; that the southern fauna though absolutely richer, may be levelled up to northern proportions as between group and group, by discovery of the smaller forms; that, for instance the crustacea may regain their supremacy over the mollusca by the recognition of numerous minute forms. So when a future census of the Sydney marine invertebrates attains symmetry by the due representation of small, neglected species, the total will exceed still further those of the northern fauna.

About 550 species of fish are recorded from New South Wales. A catalogue of this fauna was published by Mr. E. R. Waite[1] in 1904.

Of marine algæ, about 160 species have been recognised on the coast of this State. These were recently catalogued by Mr. A. H. S. Lucas,[2] who remarks that the local marine flora is poor and monotonous compared to that of colder seas. The great kelp forests of the south which may reach the surface from a depth of fifty feet are here wanting. As with the fauna, our shores are a meeting ground for

[1] Waite, Mem. N. S. Wales Naturalist Club, ii, 1904.

[2] Lucas, Proc. Linn. Soc. N.S. Wales, xxxiv, 1909, pp. 9-60; xxxvii, 1912, pp. 157-171; xxxviii, 1913, pp. 49-60.

tropical and temperate plants; several Japanese species extending thus far.

Changes of Climate and Time.

It was noticed by Darwin how the organisms of the beach leave the scantiest record in geological history. Inhabitants of the river, the lake, or the continental shelf are frequently preserved as fossils, but of the barnacles, limpets, chitons, or whelks of the intertidal zone there is hardly a trace. "The explanation, no doubt, is that the littoral and sublittoral deposits are continually worn away, as soon as they are brought up by the slow and gradual rising of the land within the grinding action of the coast waters."[1]

A rare and interesting exception to this rule of destruction is a raised beach which occurs at the apex of the Hunter delta, near Maitland. On investigation by David and Etheridge it proved to contain thirty-two species of mollusca, and one cirrhipede.[2] The interest of the collection centres on the four following shells:—*Pecten strangei*, *Brachyodontes erosus*, (=*Mytilus menkeanus*), *Euchelus atratus* and *Arcularia dorsata* (=*Nassa livida*). All these have now disappeared from New South Wales. The mussel *B. erosus* has even vanished from East Australia, though it persists as a dwarf form in Tasmania. But large specimens like the Maitland fossils still occur in the corresponding latitudes of Western Australia.

Arcularia dorsata (fig. 1) inhabits estuaries from Torres Strait to Port Curtis, while the other two reach Moreton Bay. That so large a proportion as one-tenth of this fauna should have now gone from New South Wales shows not only an appreciable geological antiquity, but also a change of climate. Such exact criteria do these fossils afford

[1] Darwin, Origin of Species, 1860, pp. 289, 291.

[2] David and Etheridge, Rec. Geol. Surv. N.S. Wales, ii, 1890, pp. 37 - 52.

that they may be read as a self-registering thermometer (fig. 2) telling that when and where they lived, a climate like that of, let us say, Bundaberg prevailed. At such a time crocodiles may have swum up the Hunter River, a *Rhizophora* forest would have flourished on its banks, and turtles may have come to the predecessor of Stockton beach to lay their eggs.

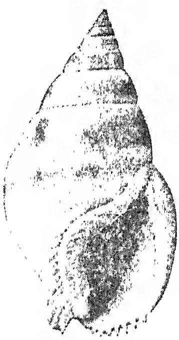

Fig. 1. *Arcularia dorsata* a member of the Maitland beach fauna.

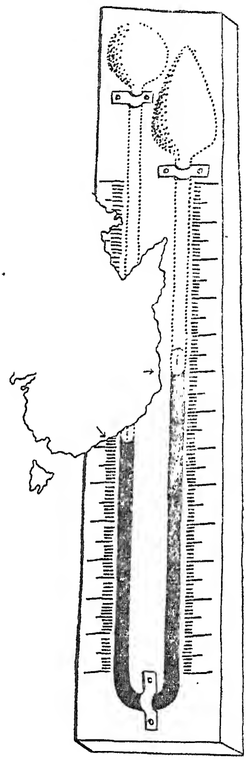

Fig. 2. Recession northwards in recent geological time of the minimum temperature required by *A. dorsata*.

While the fauna of the deep sea is probably the most conservative in the world, that of the beach zone appears to be less stable than the ordinary land fauna. The least fluctuation of temperature evokes a response from northern species pressing south and southern species moving north. Here are two armies perpetually in advance or retreat. Tropical forms such as *Bonellia*[1] incessantly attempt to colonise our coast, when the Notonectian floods the port,

[1] Hedley, Proc. Linn. Soc. N.S. Wales, xxxi, 1906, p. 462.

these gain a footing, but perish when the stream swings off shore.

Strombus luhuanus, a common and conspicuous shell on coral reefs was once abundant at the Bottle and Glass rocks. Then it disappeared from May 1865 till April 1896 when it again made its appearance.[1] A living specimen of the tropical *Bursa mammata*, Bolten (= *venustula*, Reeve) was found alive in the Harbour by T. Rossiter, but in the forty years that have since elapsed, it has not once been seen again.

After the passage of years changes occur in the distribution of species. Thus collectors constantly note that some particular species has become more or less abundant than formerly. At the time of its description (1891) *Eulimella moniliforme*,[2] was quite abundant on *Ruppia* at the mouth of the Curl Curl Lagoon. Since then I have searched in vain for a single specimen. Local history does not extend back sufficiently far to register many such changes, so the following instances are quoted from abroad. The common periwinkle of the European market, *Littorina litorea*, was unknown at Woods Hole, Massachusetts, before the year 1876.[3] Migrating from the north this periwinkle took possession of a new field, and so thrived there that in thirty years it actually became more abundant than any other shell on the beach.

In 1850 Prof. C. B. Adams examined and catalogued the mollusca of the beach at Panama, noting the position, and relative abundance of each species. Sixty years afterwards this area was re-examined by Mr. E. W. Presbrey,[4] who observed that, "Everywhere in the region covered by

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[1] Brazier, Proc. Linn. Soc. N.S. Wales, xviii, 1894, p. 432, and Hedley, *op. cit.*, xxi, 1896, p. 88.

[2] Hedley and Musson, Proc. Linn. Soc. N.S, Wales, xvi, 1891, p. 247.

[3] Verrill, Am. Journ. Sci., (3), xx, 1880, p. 251.

[4] Presbrey, The Nautilus, xxvi, 1913, pp. 121 – 125.

Adams the stations and the habits have materially changed." Where Adams had gathered 4,500 specimens of *Oliva volutella*, Presbrey got three. Adams took 1,500 *Nassa panamensis* and 330 *N. luteostoma* near the old sea wall where there are none now. Where Adams took 3,000 specimens of *Columbella* representing 29 species, there Presbrey merely saw a few individuals of seven species. It may be that this depreciation was partly caused by the opening of the Panama Canal, but the changes involve some gain as well as heavy loss. For in other cases the species noted as rare by the first investigator had become abundant in the time of his successor. *Strombus galea*, of which Adams only saw a few fragments, is now plentiful, and *Purpura* is more common than it used to be. Both *Pecten* and *Pectunculus* were rare in 1850 and common in 1913.

Striking changes which occurred in the marine fauna of Plymouth between 1893 and 1895 are noted by Mr. E. T. Browne.[1]

Changes by Epidemics and Accidents.

The desolating sweep of a bush fire is unknown in the marine world, but the sea is not exempt from destructive visitations. Our fauna though safe from being scalded by hot lava, or planed away by floating ice, has its own plagues.

Sudden and widespread mortality occurred among the sedentary intertidal organisms of Port Jackson in 1866 and again in March 1891. Oysters and mussels were completely exterminated over wide areas, the stench from the mussel beds at Watson's Bay was described as unbearable. At Little Sirius Cove all the limpets and periwinkles were found to be lying about with the animals decaying in the shells. Such forms as live under stones, the zoophytes,

[1] Browne, Journ. Marine Biol. Assoc. iv, 1896, p. 168.

polyzoa, ascidians, echinodermata and gasteropoda also suffered. In some places half the fauna was dead, in others the rocks which usually swarm with life were so deserted that only a few worms remained alive of a great congregation. Mobile creatures like fish and crabs withdrew from the putrifying beach to deeper water.

Whitelegge[1] considered that dense swarms of a microscopic red *Glenodinium* suffocated the mussels and oysters by clogging their gills. The death and decay of these bivalves, diffusing corruption in the water, spread destruction through their neighbourhood. This microbe, *Glenodinium rubrum*, appeared in March and April 1891, in such vast numbers as to discolour the waters of the harbour in long streaks and patches of blood red. So immense a development of the dinoflagellate was thought by Whitelegge to be fostered by a heavy rainfall reducing the salinity of the surface water and by a long continuance of calm weather. The final disappearance of the *Glenodinium* was due partly to the fall in autumn temperature and partly to the efforts of an allied protozoan *Gymnodinium*, which arrived to prey on it. Had the plague *Glenodinium* been colourless and consequently invisible, the disaster would have been without apparent cause.

Certain reefs, where both animals and plants suddenly and mysteriously perish, are described by the fishermen in Japan as having been "burnt." On one occasion this happened on so large a scale that the loss to the gatherers of sea-weed for food, glue, or manure, and of fish to the fishermen was estimated at £1,200 per annum per mile of the infected area. Within a few days the sea-weeds on these reefs were destroyed from low water downwards. The softer plants rotted away, while the harder corallines stood, though faded from red to white. The banks grew

[1] Whitelegge, Rec. Aust. Mus., i, 1891, pp. 179 - 192.

bare and desolate, migrant shoals of fish avoided the place, those that had lived amid the forest of brown kelp, disappeared, and molluscs including the valuable *Haliotis* also vanished.

The explanation of this phenomenon supplied by Yendo[1] is that the fresh water pouring out of a river in heavy flood was turned aside by the coastal current and projected on to the affected area. When thus immersed in fresh water, the marine algæ at once died, and their loss carried destruction to their associates.

After storms of wind and rain, I have noticed numbers of the razor-shell *Solen solanii* and the gephyrean *Dendrostoma dehamata* thrown up on a beach in Middle Harbour in a moribund condition.[2] A gale without rain does not dislodge these, so their destruction is probably caused by poison of tannin or other deleterious matter from decayed plants.

Transition from Marine to Terrestrial.

It is agreed that all terrestrial organisms had a marine origin. The beach is at last the font of all life whether aerial, fluviatile, terrestrial, pelagic or abyssal. In the higher animals, vestigal features demonstrate that respiration was aqueous before it was aerial.

Dr. A. B. Macallum[3] considers that the difference in chemical composition between blood and salt water is slight, and that the Paleozoic Sea being poorer in magnesium, was still more like blood than is the existing sea water. He concludes that a circulatory system, once open to the sea, of a marine vertebrate ancestor became closed, and that the animal, then migrating ashore, carried with it a

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[1] Yendo, Econ. Proc. Roy. Dubl. Soc. ii, 1914, pp. 105 - 122.

[2] Hedley, Proc. Linn. Soc. N.S. Wales, xxv, 1899, p. 432; and Kesteven, Rec. Aust. Mus., v, 1903, p. 69.

[3] Macallum, Trans. Canad. Inst., vii, 1904, p. 535.

supply of sea water perpetuated by heredity. Every vertebrate thus maintains its viscera in a bath of warm sea water and its very life depends on that aquarium being kept unbroken. So in this way we are all sea creatures still.

If it had been upon the land that an animal first made bones there would have been at its disposal such hard substances as iron or aluminium, while to a marine animal the softer calcium was the best material available.[1] Hence for the building of a firm frame it was lime that was employed by all sea dwellers, the worms, the crabs, the snails, and finally the vertebrates. The suggestion is that this choice of lime for a skeleton was made by vertebrates before migrating from the sea to the shore, after which its use became a fixed habit.

At times the land has repaid the sea, as in the case for instance, of the whales, dugong, seals or sea-snakes which had terrestrial origins. There are two roads from the sea landwards, the easiest and most gradual way is to ascend a river and undergo the transformation in marshes. The other is to make the beach a changing ground, where may be learned how to endure a greater change of temperature, to support the body in a thinner medium and to breathe air. Where a sea was tideless, there would be little opportunity for transformation, and in proportion as the tide had a larger range, so would be the facilities for change. Probably the process of acclimatisation from sea to land was chiefly through the estuaries, and an animal has rarely grown independent of the water by traversing the beach. The ocean existed, of course, before the rivers. Both these routes are practised here. In the streams, fish like *Galaxias attenuatus* and the Blue-eye, *Pseudomugil signifer* pass from salt to fresh water, and back again.[2]

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[1] Johnstone, Conditions of life in the Sea, 1908, p. 301.
[2] McCulloch, The Australian Zoologist, i, 1915, p. 47.

In mangrove swamps are numerous air breathers, which are immersed frequently, yet do not venture beyond the farthest reach of the sea, these include the slug *Onchidium*, the snails *Salinator* and *Ophicardelus*. In the tropics this amphibious fauna multiplies and includes fish in the case of two species of *Periopthalmus*, crustacea as *Cœnobita spinosa*[1] and *Uca*, mollusca as *Cerithidea*, *Melaraphe* and *Truncatella*. Indeed migration from the sea to the shore, or from salt water to fresh, is easier and more frequent in a warm climate than in a cold one.[2] On Funafuti I found *Nerita plicata* packed together in crevices of the rocks far above high tide mark, behaving like a terrestrial rather than a marine animal.[3]

All over the world the molluscan family Littorinidæ, are pioneers in emergence from the sea. Pelseneer describes how the gill plume of a European species is shortened and broadened to form an incipient lung.[4] Quoy and Gaimard,[5] observed that the ctenidium of *Littorina angulifera* had shrunk from disuse in consequence of living more in the air than in the water.

A correlation between the station on the beach, and embryonic life of different species is traced by Mr. W. M. Tattersall,[6] as follows:—"Of the four British species of *Littorina*, *L. litorea* is exposed only at low spring tides, and is freed as a trochosphere, later becoming a veliger; *L. obtusata* is generally exposed at ordinary low water, and is freed as a veliger; *L. rudis* is exposed during the greater part of the day, and is viviparous; *L. neritoides* lives between the high water of springs and neaps and is also

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[1] McCulloch, Rec. Aust. Mus., vii, 1909, p. 303, pl. 88.

[2] Origine des Animaux d' eau douce, Pelseneer, Bull. Acad. Roy. Belg. 1905, p. 724.

[3] Mem. Aust. Mus., iii, 1899, p. 409.

[4] Pelseneer, Mollusca, 1906, p. 104.

[5] Quoy and Gaimard, Zool. Astrolabe, ii, 1833, p. 476.

[6] Tattersall, Nature, vol. lxxix, 1909, p. 478.

viviparous. Both in habit and life history these four seem to represent stages in adaptation to a land existence."

On this coast the littorinoids in ascending order are:—*Bembicium melanostoma*, *Melaraphe acutispira*, *M. infans*, *M. mauritiana*, *Tectarius pyramidalis*, and *Melaraphe scabra*. It would be interesting to prove if Tattersall's generalisation connecting larval history with beach horizon holds good in Australian seas also.

In his charming account of the animal ecology of the Cold Spring sand-spit, Prof. C. B. Davenport[1] relates how, near New York, *Littorina palliata* clings to the stems of the marsh grass, *Spartina polystachys*, and how near New Orleans *L. irrorata* climbs the rushes. He suggests that the lack of a siphon exposed *Littorina* to the danger of suffocation by mud, and that escape from the mud induced a habit of climbing. Thus it started on the road to adaptation to a terrestrial life—"a road that the Pulmonates must have travelled long ago."

Fig. 3. *Avicennia* branch supporting sea-snails, *Melaraphe scabra*, on the leaves.

[1] Davenport, Decennial Publ. Univ. Chicago. x, 1903, p. 168.

A remarkable expression of the landward migration of the littorinoids is *Melaraphe scabra*, whose special haunt is the leaf of the mangrove (fig. 3). More than two centuries ago Rumphius, who saw it in the Moluccas called it *Buccinum foliorum* in allusion to this habit. The variety *filosa* was gathered in November 1847 by Macgillivray on the leaves of *Ægiceras* at Port Curtis.[1] A depauperated form called *luteola* by Quoy and Gaimard occurs on *Avicennia* about Sydney and Port Stephens. Its tropical companion *Cerithidea* which perches on the boughs and twigs of the mangroves does not descend so far south.

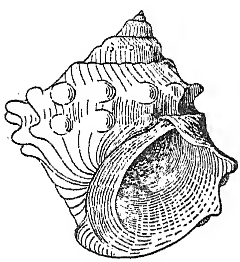

Fig. 4. *Tectarius pyramidalis*, the highest climber from the sea on the ocean beach, magnified.

Exposed to the hottest sunshine and watered only by spray or by the highest tide, *Tectarius pyramidalis* (fig. 4) creeps furthest in the ascent of the ocean rock beach. Kesteven observed that its osphradium has degenerated so as to be almost useless, he thought that the animal was protected against evaporation by an abundant secretion of mucous, sealing up the mouth of the shell.[2]

In the estuary the boundaries of land and sea overlap, though a wide neutral zone separates them on the rocky ocean beach.

To the amphibious fauna of the transition area, the mangrove swamp contributes the Auriculidæ, the rocky beach supplies the littorinoids and the ocean sand beach has for its representatives the swift-sand-crab *Ocypoda* (fig. 8) and the sand-hoppers of the family Orchestidæ.

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[1] Rumphius, Amboinische Rareitkamer, 1705, p. 98; Forbes, Voy. Rattlesnake, ii, 1852, p. 362.

[2] Kesteven, Proc. Linn. Soc. N.S. Wales, xxvii, 1903, p. 621.

Types of Beach.

THE SHINGLE BEACH.

The desert of the shore is a shingle beach. In the wash of the waves, each pebble grinds its neighbour's face, so that any plant or creature seeking a home among the stones would soon be bruised to death. Such beaches are rare in this State, the nearest to Sydney is a shingle beach at Kiama.[1]

THE OCEAN SAND BEACH.

Next in order of importance is the sandy beach facing the ocean, which contains a small and highly specialised fauna, but no visible flora. Here in New South Wales, as elsewhere, the fauna of the mud or of the rocks is far richer than that of the sand.

Sandy beaches occur along the whole of our coast line. North of Newcastle they extend with brief interruptions to the Queensland border, south they alternate with the rocky headlands. The changefulness of the local beach front has been well described by Mr. E. C. Andrews.[2]

In all countries and various climates the ocean sand beach preserves the same external appearance. If, by some cosmic change, the climate of Sydney became warmer, then in response a thicket of *Rhizophora* would spring up on the zostereta of Middle Harbour, and reef corals would build on the hormosireta of the Heads. But the sandy beach though sheltering another series of species, and perhaps serving as a turtle incubator, would still remain unchanged externally.

It was proposed by Prof. Davenport to group the intertidal fauna by companies of sessile, crawling, burrowing,

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[1] The shape of pebbles has been studied by H. E. Gregory, Am. Journ. Science, xxxix, 1915, p. 300.

[2] Andrews, this Journal, xlvi, 1913, pp. 158 – 185.

or swimming animals. Though useful in the area for which it was suggested, this classification is not of general application. Progression methods are not as sharply defined in the dense water as in the thin air, thus the glide of a marine animal may change imperceptibly from crawling to swimming. Neither areas nor animals can be definitely arranged thus, for the upper rock zone is deficient in burrowing and swimming species. A Cephalopod might appropriately enlist in every company. Finally the sand-surf organisms do not strictly belong to any particular class, yet all might qualify for each.

No marine community leads so strenuous a life as does the sand beach fauna. In the sand-democracy organisms are independent, there are no dominant types like *Cynthia*, *Ostrea* or *Galeolaria* to afford protection to the weaklings. Since there are no plants, the animals are necessarily carnivorous; since the even surface offers no shelter, the only means of refuge is to plunge under the sand. Existence in the surf-line can be maintained only by great strength, constant activity and watchfulness. An instant's weakness, a moment's relaxation may bring destruction either from being seized by a prowling fish, or from being thrown high and dry upon the shore by the next wave. To resist a blow the shells of the sand-dwellers are solid, to dive quickly into the sand, they are smooth and tapering.

Characteristic of the sand beach is the handsome white and purple *Donax deltoides* (fig. 5), which in New South Wales is called the "pipi," and in South Queensland is known by the local aboriginal name of "ugari." Pipi is a Polynesian word which has been adopted from the Maori. In New Zealand pipi means *Mesodesma australe*, and in Samoa it signifies *Asaphis deflorata*.[1] Stacks of shells in

[1] Bulow, Internat. Archiv. Ethnograph., xiii, 1900, p. 184.

aboriginal camping grounds show it to have furnished many a meal to the extinct black race. Local fishermen use it for bait.

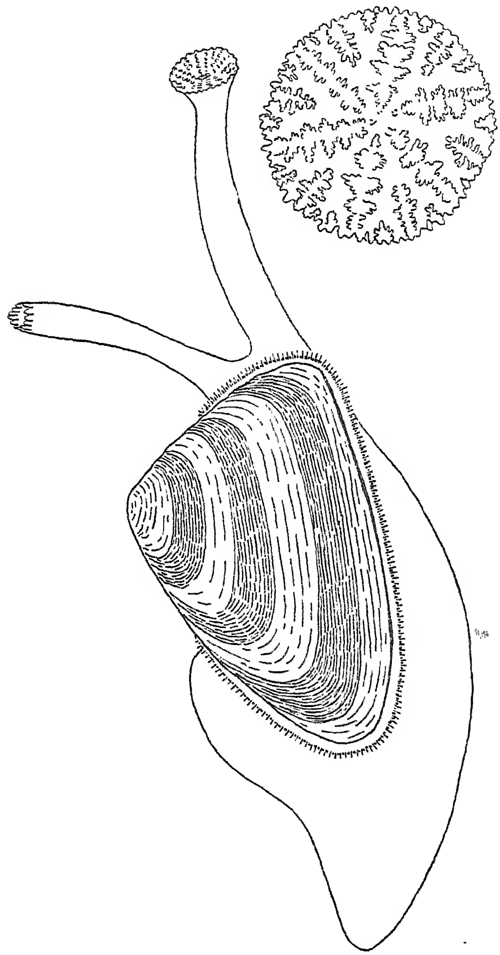

Fig. 5. The pipi, fully extended, with the disk of the inhalent siphon magnified.

This *Donax* lives only in the wash of the surf where it occurs in companies about low tide level. To adapt itself to this existence, to quickly dig itself into the sand and

save itself from hurt, the *Donax* has assumed a thick shell with a wedge shape and a slippery surface. The animal is extremely strong and active, when outstretched, the foot is as large as, and the siphon longer than, the valve. A few drives of the powerful flat pointed foot draws the creature under the sand. Here it stands upright, with the extended siphons held aloft, their tips alone projecting above the ground. The orifice of the inhalent siphon expands in a disk beset with minute branched papillæ. Of these there are six main rays with secondary and tertiary intermediates on the margin. Perhaps the papillæ grasp small but struggling animals. The exhalent siphon has no disk, its margin is fringed with papillæ. A parasitic crab, perhaps an undescribed species of *Pinnotheres*, infests the *Donax*. The mollusc is caught and eaten by the Red-bill, *Hæmatopus longirostris*. This bird breaks off the anterior end of the

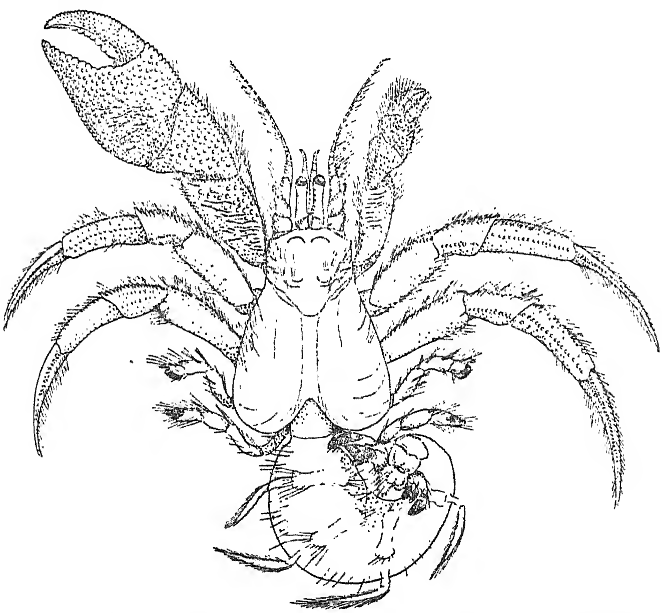

Fig. 6. Hermit crab of the sand beach, *Diogenes custos*, magnified.

left valve to extract the meat.[1] The sand in which the *Donax* lives is coarse and uneven, I find that the grains are usually half a millimetre in diameter, but vary from a quarter to a whole millimetre. A similar station is occupied in New Zealand by *Mesodesma*,[2] which from an unlike stock has acquired a general superficial resemblance.

In the summer a hermit crab *Diogenes custos* (fig. 6) makes its appearance in the surf zone of the sand beach.

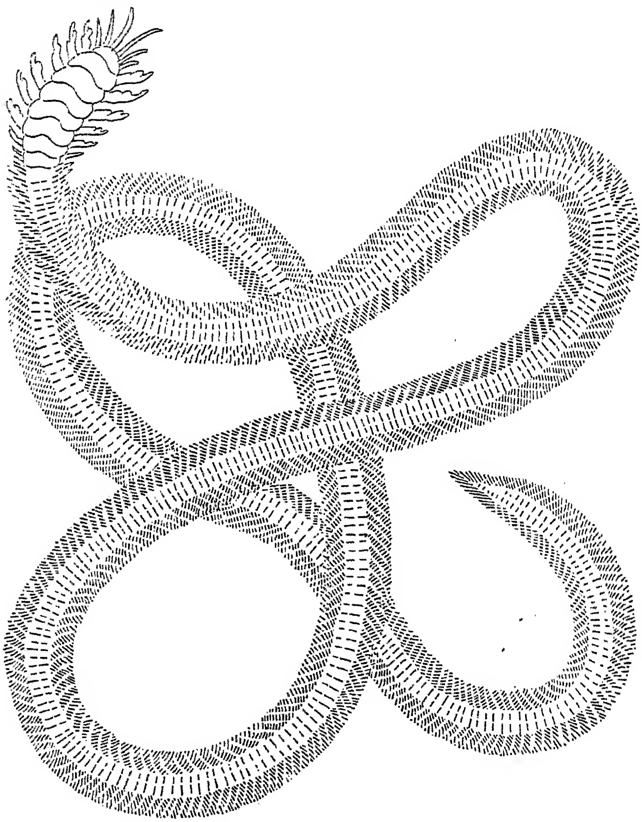

Fig. 7. The sand-beach worm *Onuphis teres*.

[1] North, Nest and Eggs Australian Birds, iv, 1913, p. 261.

[2] Bell, The Wilds of Maoriland, 1914, p. 23.

Probably after the breeding season it retires to deeper water.

One of the most notable inhabitants of the ocean sand beach is a gigantic Eunicid worm (fig. 7) well known to fishermen as excellent bait. Prof. J. H. Ashworth has kindly identified this for me as *Onuphis teres.*[1]

Bait gatherers sweep a lump of meat across the wet sand at low tide. The worm detecting this, neither by sight nor smell, but by, as Dr. H. G. Chapman terms it,[2] a "gustatory stimulus," rises from beneath the sand, darts out its head, and grips the meat. Still holding the meat in his left hand, the fisherman adroitly whips the worm out of the sand with the right. Considerable skill and smartness are needed to pull the worms out this way. Fishermen say that these worms reach a length of five feet.

One member of the beach society has forsaken its native element for a terrestrial existence. This is *Ocypoda cordimana* (fig. 8), a small grey crab with square deep body

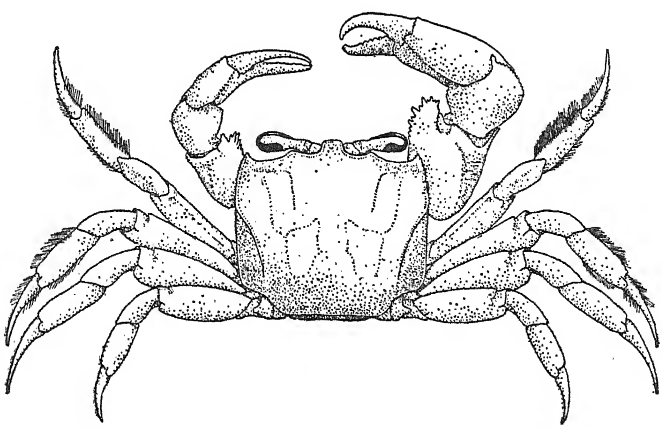

Fig. 8. The swift sand-crab, *Ocypoda cordimana.*

[1] Ehlers, Die Borstenwürmer, i, 1868, p. 293.

[2] Chapman, Proc. Linn. Soc. N.S. Wales, xxxix, 1915, p. 649.

and long slender limbs.[1] Across the beach the swift sand-crab races like foam blown before the gale. And when it stops, so closely does its colour match that of the sand that it can scarcely be detected. This crab breathes through a special pore between the third and fourth pair of legs, and has become so dependent on the air, that it would drown if kept long under water. It digs a deep spiral burrow in the dry sand above the wash of the tide, and feeds on the carcases which the sea throws up and the flies attracted thereto.

Under masses of decaying sea-weed at the storm drift-line swarm the amphipods *Talorchestia quadrimana* and *Ochestia macleayana*.[2]

THE MUDDY ESTUARY.

Between the ocean beach and the flats grassed by zostera there is a transition region, passing gradually from rough to calm and from sand to mud. As more shelter is secured the conditions of life become easier, more stability is gained, vegetation appears and the consequent food and safety induce an increase in the fauna. Intermediate sand flats are apt to be arranged in low bars and shallow pools. Here is the *Mycteris-Polinices* zone. The sand is here a little muddy, more loosely packed than on the open beach, and is usually ribbed by the retreating tide.[3] Such sand ripples are seen through the water in the lower left corner of Plate VI.

These flats are the parade grounds of a small blue crab *Mycteris longicarpus* (fig. 9) which marches in squadrons. Their ordinary progress is deliberate, but if pursued they

[1] For this, and the other drawings of crabs, I am indebted to my friend Mr. R. Kinghorn.

[2] Haswell, Proc. Linn. Soc. N.S. Wales, iv, 1880, p. 248.

[3] The formation of ripples on a sandy shore has been discussed by Dr. A. P. Brown, Proc. Acad. Nat. Sci. Phil. lxii, 1912, p. 536.

break into the double, and if still harder pressed the whole troop burrows into the ground, with a spiral motion and vanishes from sight.[1]

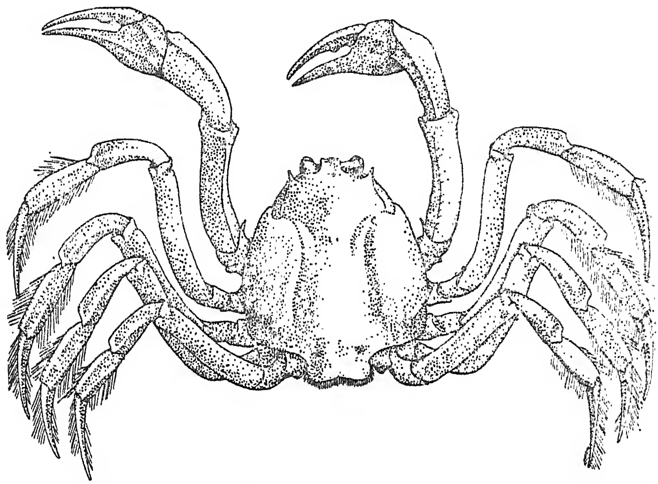

Fig. 9. The military crab *Mycteris longicarpus*, from the estuary mouth.

Another characteristic form is the subterranean snail *Polinices plumbeus* (fig. 10). Crooked furrows in the sand,

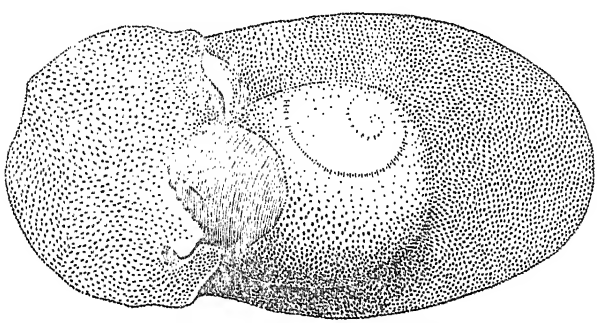

Fig. 10. Subterranean snail *Polinices plumbeus*, fully extended.

sometimes a couple of feet in length, show where the mollusc has burrowed, an inch or so beneath the surface.

[1] Saville Kent, Naturalist in Australia, 1897, p. 242.

In proportion to the shell this animal is capable of enormous extension and quite conceals the shell when outstretched. If hooked out of its burrow the fore foot doubles on the hind as the animal is slowly swallowed by the shell, finally the operculum, closing in on the snail, reveals the dull red patch of callus by which the species is recognised. When extended and in action, a thin spade, like a disk of a planarian, cleaves a way through the sand. This fore foot is then brought up like a mask before the shell, over its edge waver a pair of blind lash-like tentacles. On either side the mantle may be puckered to a pipe, an improvised inhalent or exhalent siphon. From behind, the elastic operculigerous lobe is drawn, like a hood, over the spire of the shell, and then forward till it underlies the mask. In the rear the hind foot spreads a thin disk like that in front for a shell's breadth behind. It seems to prey on the bivalve *Spisula parva*, small specimens of which I have found in its grasp. Copulation occurs when submerged under the sand. Quantities of this mollusc are consumed by sharks and rays as evinced by the undigested opercula in their stomachs.[2]

The sand in which *Polinices* burrow is finer and more even than that where *Donax* live. Both the *Polinices* and the *Arca* figured in this paper were obtained from the west side of the sand spit of Middle Harbour. I find that a sample from this locality had grains averaging 0·3 mm., with 0·5 mm. for especially large grains, and 0·2 for especially small ones. The Heart-Urchins, *Echinocardium* and *Maretia* inhabit a much lower horizon in the sheltered-sand-zone.

The most important biological feature of the estuary is the tidal forest, which in the latitude of Sydney (33° 50′) is restricted to two kinds of mangroves, *Avicennia officinalis*

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[2] Waite, Rec. Aust. Mus., iii, 1899, p. 134.

nd *Ægiceras majus*. The latter grows as a bush, with sweet-smelling white flowers, on the inland border of the mangrove swamp. Though *Avicennia* has here outstripped its tropical associates, *Rhizophora*, *Bruguiera*, *Ceriops* and *Acanthus*, yet it is well within its boundaries, for it continues south as far as Wilson's Promontory. In New Zealand it reaches Tauranga, and in West Australia it extends to Bunbury.[1] These limits doubtless correspond to isothermal zones. Even near Sydney the foliage is sometimes touched by an occasional frost.

The *Avicennia* is a slow-growing tree whose proper home is the soft black mud on the banks of saltwater creeks, but which sometimes grows on the sandy border of a zosteretum. It requires shelter and ventures on no beach unless land locked from the sea. In the distance an *Avicennia* forest, rising in domes about thirty feet high, has a resemblance to an olive grove. The short trunk branches into crooked boughs, well clothed with grey-green leaves, and casting a dense shade. As the wind stirs the foliage their pale undersides paint ashy ripples across the forest. At high tide the leaves dip in the sea (Plate I, fig. 1), while low tide exposes the pneumatophores or "cobbler's pegs" as they are called popularly. These project densely from the underlying radial roots to about eight inches above ground (Plate I, fig. 2).[2]

So safe a perch above the suffocating mud do these asparagus-like rootlets afford that they are sometimes loaded with oysters or bristle with barnacles, *Balanus trigonus*. The trunks of the trees are not neglected as residential sites, and are well plastered with oysters. An *Avicennia* leaf, which though less than three inches long,

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[1] Alexander, Nature, June, 1913, p. 399.

[2] For this and other photographs of beach scenery I am indebted to the kindness and artistic skill of my friend Mr. A. R. McCulloch, who also drew for me the two fish.

held fifty small oysters, was described and figured by Saville Kent from West Australia.[1]

The soft black mud of the mangrove formation is only suited to a small and special fauna. Whole classes are absent, for the mangrove country is shunned by all the Echinodermata, the Actinozoa, and the Sponges. This territory is occupied by a special group of mollusca, mostly air-breathers, usually with solid dull-coloured shells, especially by the family Auriculidæ. These range from the fringe of glass wort, locally called "samphire," *Salicornia australis*,[2] along the high-tide mark downwards as far as the *Avicennia* grows. Here too, as described previously, sea-snails climb aloft to the greatest height they reach above high water. This *Avicennia* belt is inhabited by the following molluscan genera:—*Onchidium*, *Salinator*, *Melaraphe*, *Zafra*, *Assemania*, *Tatea*, *Potamopyrgus*, *Plectotrema*, *Rhodostoma*, *Leuconopsis*, *Ophicardelus*, *Ostrea*, *Modiolaria*, and *Modiola*. In the autumn, schools of a marine hemipteron, *Halobates whiteleggei*, skim over the surface of the mangrove creeks.[3]

Seawards of the tidal forest, there usually occurs an area of soft mud, here is the *Holœcius-Pyrazus* zone. *Holœcius cordiformis* (fig. 11) is a small active crab with a purple claw.

Between the falling and the rising tide, it burrows and builds with such energy that the whole field is covered with little pits and heaps of mud pellets like worm castings on a lawn. The celerity with which the crabs dart to their holes shows a familarity with danger. At low tide they are

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[1] Kent, Rep. Austr. Assoc. Adv. Sci., iii, 1891, p. 554.

[2] An almost pure association of *Salicornia*, a "Salicornietum," extends for several square miles at the south-east corner of Botany Bay.

[3] Skuse, Rec. Austr. Mus., i, 1891, p. 174.

vigorously hunted by such enemies as gulls, herons, bitterns and rats.

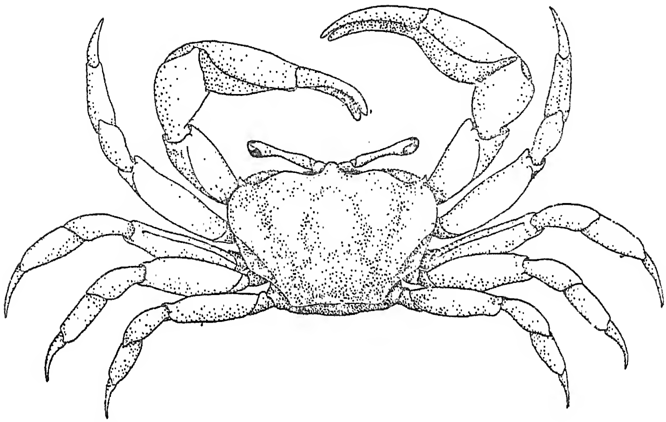

Fig. 11. The mud-flat crab, *Holœcius cordiformis.*

Their neighbour the Sydney Whelk, or Hercules Club, *Pyrazus herculeus,*[1] is more lethargic. This brown massive and knobbed shell, three inches long is strewn about in great number (text fig. 12, and Plate VII, fig. 12). Opposite the aperture the shell is broadened by a varix which forms a sole to support it from sinking too deeply. Oysters and barnacles sometimes ride on the back of the shell.

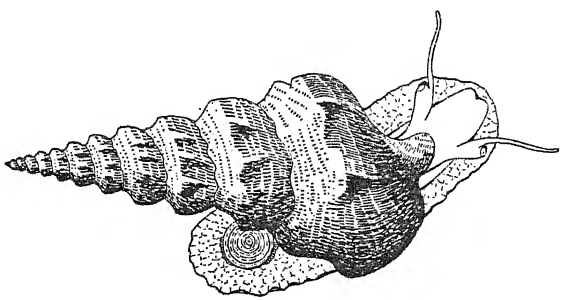

Fig. 12. The Hercules Club shell, *Pyrazus herculeus,* from the open mud flat.

[1] Hedley, Proc. Linn. Soc. N.S. Wales, xxx, 1906, p. 529.

The solid shell it carries is armour proof against the jaws of fish, the beaks of gulls, or the teeth of rats, and the rays of the sun. Both crab and snail live on the bare ground. Though no food is visible it may be that each tide in a layer of silt spreads a table of microscopic provender. The zones of *Melaraphe* and of *Donax* share this feature of exhibiting no apparent vegetation. In the tropics this zone carries a larger fauna and includes the amphibious fish *Periopthalmus*, and the brightly coloured calling-crab, *Uca*, and the gasteropod *Telescopium*.

Along the calm and sheltered reaches of Botany Bay, Port Jackson, or Broken Bay, there flourish marine meadows of *Zostera*, *Posidonia*, and like plants with ribbon blades, known as grass-wrack or eel grass. The commonest species is *Zostera nana*[1] (fig. 13). These species flower here only on very rare occasions; during the last twenty-five years I have found *Posidonia* in blossom only once and never *Zostera*. Their dense foliage smothers any intruders, so that they occur almost as a pure formation. Such an association is termed a zosteretum[2] (Plate II, fig. 3).

Under the microscope, the leaf blades of the Zostera develop into a zoological garden, so overgrown are they with minute plants and animals. The fauna of the Zostera beds near Marseilles was described by Prof. Marion.[3] Dr. H. C. Ostenfeld has produced an exhaustive memoir on the Ecology of Zostera in Danish waters.[4] He finds it to support an epiphytic flora of small sea-weeds and diatoms and a fauna of small gasteropods and bryozoa. There it is the principal source of the organic matter of the sea bottom.

[1] This and the *Ruppia* were kindly identified for me by Mr. J.H. Maiden.

[2] Warming, Œcology of Plants, 1909, p. 230.

[3] Marion, Ann. Mus. Marseille, i, 1883, p. 71.

[4] On the Ecology and Distribution of the Grass-wrack, *Zostera marina*, in Danish waters. Report Danish Biological Station, xvi, 1908. See also Petersen, Reports xx, 1911, and xxi, 1913.

The zosteretum flourishes on mud banks, where there is a considerable admixture of sand. At low spring-tide this vegetation is laid bare, thence it continues downwards for

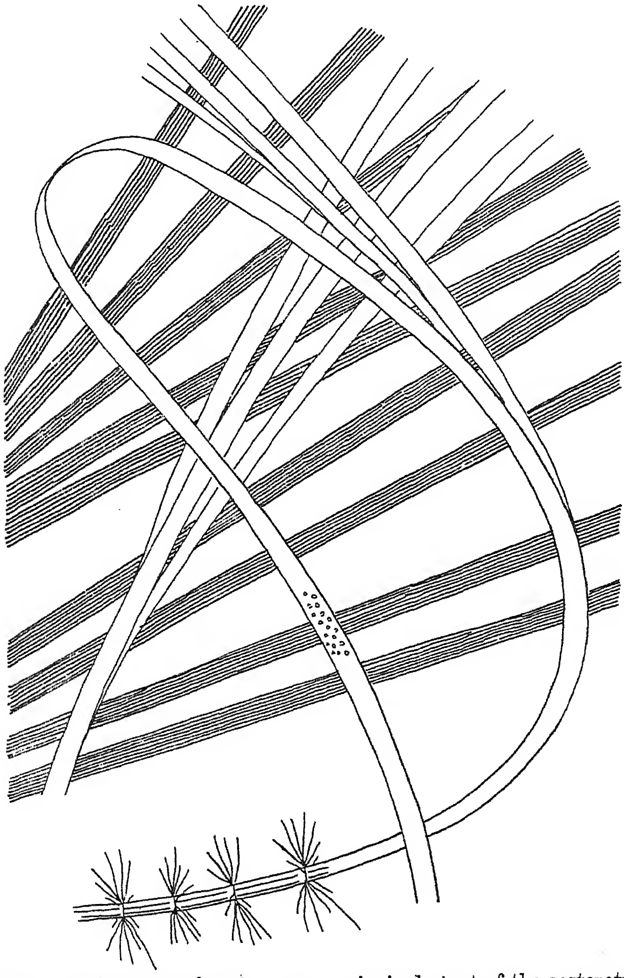

Fig. 13. Blade-leaves of *Zostera nana*, principal plant of the zosteretum.

several feet. Before the advent of civilisation disturbed the balance of nature, the dugong *(Halicore dugong)* would

sometimes browse on the marine pastures of Botany Bay and furnish a meal to the blacks.[1] *Posidonia* leaves are sometimes rolled and felted together by the waves into compact balls; their fibre has lately been utilised in the manufacture of cloth.[2]

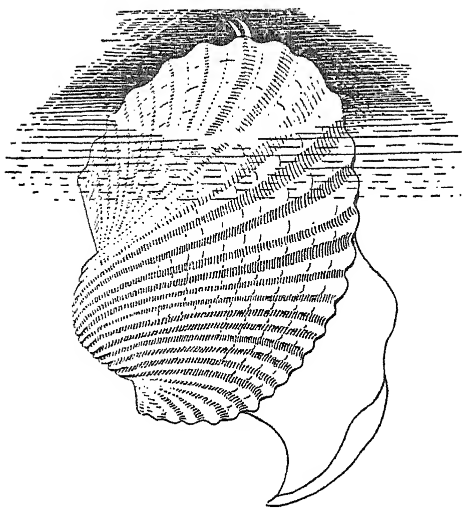

Fig. 14. Mud cockle, *Arca trapezia,* with foot extended and branchial tips exserted. The anterior end projects above the surface of the mud flat, the rest is buried beneath.

Characteristic of the local zostereta is the Sydney Cockle, *Arca trapezia*, a massive boat-shaped, ribbed, white shell (fig. 14). The animal, which protrudes a large foot with a distinct sole but no byssus, is orange-red, it is sluggish in its movements and usually rests sunk in the mud for three-quarters of its length, often bearing a tuft of weed to mask the projecting anterior end. The tips of the branchiæ protrude above as short slender wavering tentacles. Influence of environment is shown by its features. For the purpose of diving quickly into the sand the shell of *Donax* is smooth and wedge-shaped. But *Arca*, being constructed to float on the surface of the mud, is moulded posteriorly with a swell like a buoy and girdled with nodul-

[1] Etheridge, Rec. Austr. Mus., vi, 1905, p. 17.

[2] Lucas, Proc. Linn. Soc. N.S. Wales, xxxiv, 1909, p. 498; Baker, *op. cit.*, xxxv, 1911, p. 804.

ous keels to prop it up. The more sedentary habits bring less development to the foot than in the strenuous *Donax*. Projecting as it does above the mud, no siphon is required by *Arca*. Great stacks of shells about the old aboriginal camps show how important an article of food it was to the blacks.[1]

This species is related to a tropical section of the genus and indeed itself reaches the tropics, showing it to be a northern constituent in our fauna. Though so common in New South Wales, both this and *Pyrazus* are absent from zostereta in the corresponding latitudes of South Australia. At Dry Creek near Adelaide, Mr. W. Howchin finds that up to a recent geological date *Arca trapezia* was abundant, but that it had suddenly and completely vanished, before the time of the last deposit.[2]

It is now suggested that its extinction, and that of its neighbour *Pyrazus*, in South Australia are due to refrigeration, and may mark a period in geological climate and time subsequent to that of the Maitland raised-beach. The last cold phase was reckoned by Prof. David from the Kosciusko moraines to be from three to ten thousand years past.[3]

The surface of the mud flats inhabited by *Arca* was exposed to the full severity of the cold when a frosty night coincided with low tide. Such cold would not be fatal to other species formerly associated with it in St. Vincents Gulf and now surviving there, as *Ostrea angasi*, because they descend to the depth of a few fathoms. On the Pacific coast, as the cold maximum approached, the *Arca* could escape by retreating as far north as was necessary,

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[1] Hedley, Proc. Linn. Soc. N.S. Wales, xxix, 1904, p. 203.

[2] Howchin, Trans. Roy. Soc. S.A., xxxvi, 1912, p. 36.

[3] David, Helms, and Pittman, Proc. Linn. Soc. N.S. Wales, xxvi, 1901, p. 64.

and when the cold relaxed, could return to repopulate the former situation (fig. 15). But in South Australia, a northern retreat was cut off by the concave coast, so that when locally exterminated by frost there could be no return of exiles when conditions improved.

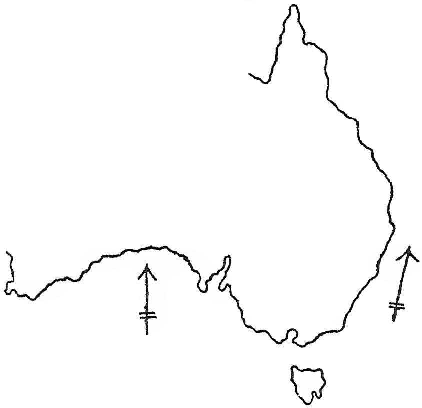

Fig. 15. Map of *Arca* retreat during the cold phase. While on the east the route is open, on the west it is intercepted by the concave coast of the Great Australian Bight.

Besides the *Arca*, a considerable and varied fauna is supported by the zosteretum. A small carnivorous gasteropod, an active scavenger, inhabiting a shell half an inch long is *Arcularia jonasi* (fig. 16). With

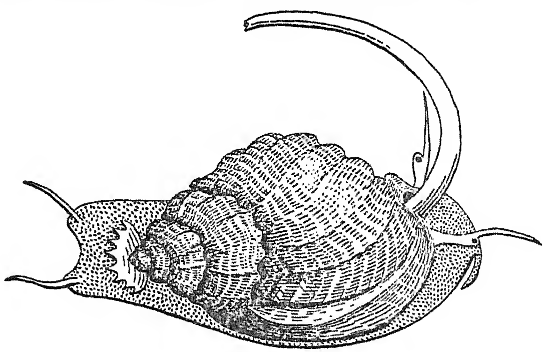

Fig. 16. *Arcularia jonasi*, a common carnivorous snail of the zosteretum. It is fully extended, in the act of gliding over the mud or weed; much magnified.

great energy it glides rapidly over the sand and weed, carrying its long siphon so strangely resembling an elephant's trunk, sometimes erect, sometimes arched over its back.

The eyes are mounted half way on stalks which finish as slender lashes waved incessantly hither and thither. On the tail are planted two waving filaments, while the front margin of the foot is also provided with a pair of processes. A triangular shell about eight inches long, related to the mussels is *Pinna menkei*. Its habit is to sink upright in the mud, and to present to a bare footed visitor a thin concave blade capable of inflicting a severe wound. Among the narrow zostera leaves lies commonly hid the slender zostera Pipe-fish *Stigmatophora argus* (fig. 17). So like is

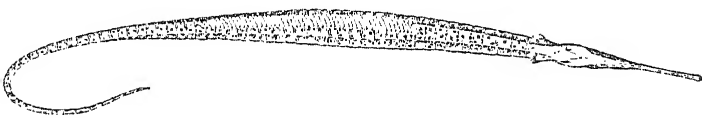

Fig. 17. The Pipe-fish of the zosteretum, *Stigmatophora argus.*

this to its natural surroundings that, whether straight or curled, the eye can scarcely detect it even in full view. And if detected and pursued the Pipe-fish escapes from every enemy by diving into the dense weed. The males carry the incubating eggs in a pouch on the tail.

Occasionally the zosteretum is invaded by the Bubble-weed, *Colpomenia sinuosa.*[1] This pest spreads over the flat, smothering other vegetation and attaching itself to the oysters, whelks or cockles. When the gas forms in the expanding balloon it lifts the shell and floats it away, so that oyster plantations are sometimes seriously denuded by its agency.

A peculiar development of the zosteretum formation is the ruppia-lagoon, of which Deewhy Lagoon (Plate VI) a few miles north of Sydney may be selected as a typical example. Here a sand-bank thrown up by the surf has dammed the mouth of a small stream. Behind this barrier the water accumulates in a shallow brackish lake, several

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[1] Stead, Proc. Linn. Soc. N.S. Wales, xxxvi, 1912, p. 632.

acres in extent. At intervals of weeks or months, the lake is swollen by rain and breaks through the sand dam, the lake is partly drained, the sea enters, the waves restore the barrier and the cycle recurs. Such a sheet of water has an extreme range from salt to fresh and from warm to cool. On a level floor two or three feet deep is a dense monotonous carpet of the slender threads of *Ruppia maritima.* The fauna is a scanty one. In Deewhy Lagoon I collected the following mollusca:—*Tatea rufilabris*, *Potamopyrgus ruppiæ*, *Salinator fragilis*, *Modiolaria subtorta* and *Erycina helmsi.*

Such a lagoon is a favourite resort of waterfowl. The following list of the birds which frequent such a lagoon and adjoining beach was kindly drawn up for this article by Mr. A. J. North:—*Pelecanus conspicillatus*, *Plotus novæhollandiæ*, *Sula serrator*, *Phalacrocorax carbo*, *P. melanoleucas*, *P. sulcirostris*, *Chenopis atrata*, *Anas superciliosa*, *Biziura lobata*, *Hæmotopus longirostris*, *Charadrius dominicus*, *Numenius cyanopus*, *Tringa acuminata*, *Sterna bergii*, *Gabianus pacificus*, *Larus novæhollandiæ*, and *Podiceps novæhollandiæ.* Parasitic cycles alternating between sea fowl and marine invertebrates such as have been elaborated in Europe,[1] will probably be discovered here also.

THE OCEAN REEF.

Rocky ground facing the open sea supports the richest flora and fauna. For here the water is most thoroughly ærated by the surf; here is the greatest safety from mud, so inimical to many marine creatures, and here is the first landing place for immigrant spores and larvæ, transported by winds and currents from abroad.

Contrasting with these advantages is the constant danger of being swept away by the waves. The surf that breaks

[1] Lebour, Parasitology, iv, 1911, pp. 416 – 456.

upon this open coast is heavier and more forceful than that seen on most European shores. A striking instance of its power is recorded by Mr. C. A. Süssmilch,[1] who described and illustrated a block of sandstone at Bondi, 20 feet long, 16 feet broad, and 10 feet high, estimated to weigh 235 tons, which was capsized, dragged 50 yards and lifted 10 feet during a gale.

Marine organisms which have to endure such fury as tossed this block at Bondi, undergo special adaptation. In the first place they are skilled at taking cover, appreciating to the full the shelter afforded by a tuft of weed, a crack or a projecting ledge of rock. Without such shelter existence would for most be here impossible.

Evolution has conducted various inhabitants of the surf-zone by epharmonic convergence to the same tent-like shape. Just as a similar mode of defence has imposed a superficial resemblance on the hedgehog and the Echidna, so resistance in the sea has moulded many different stocks to the same external form. Though of unlike origin and widely different in anatomical features, the gasteropods *Emarginula*, *Siphonaria*, and *Acmaea* have now assumed a shell hardly to be distinguished on the outside from the real limpet. Travelling an even longer road, the barnacle has changed from a mobile crustacean to a fixed limpet-like cone. For example, *Catophragmus polymerus* (fig. 18), common in the surf zone and distinguished by its whorls of scales, like a daisy's petals, shows the last stage of transition from a stalked to a sessile barnacle, as if it were a telescoped *Scapellum*. The limpet itself is doubtless the last term of a series of trochoidal, multispiral gasteropoda.

For this low cone or tent shape is that on which rushing water takes the least grasp, the stream shearing off from its evasive sides. As a further mechanical advantage, the

[1] This Journal, xlvi, 1912, pp. 155 – 158, pls. iv, v, vi.

wall of the cone may be strengthened by radial corrugations. If a stream be received on one side only, the shell develops a long front slope, and steep rear, but where the pressure is endured on various aspects the apex is central and the shell symmetrical. So in the rapid mountain streams of the tropics, *Navicella* has for the same purpose evolved from *Neritina* to a limpet like shell.

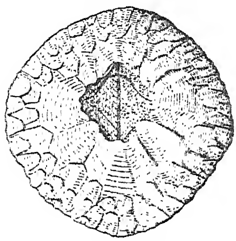

Fig. 18. *Catophragmus polymerus*, a sessile barnacle from the surf zone. Showing descent from a pedunculate form modified to a limpet shape to resist the blows of the waves.

By adaptation to surf environment the limpet has thus arrived at the best shape for resistance. A group of limpets *Helcioniscus variegatus*,[1] is shown by Plate V, fig. 10, as planted on a bare space of rock exposed to the full sweep of the ocean surf at Long Reef. Here there is not the least cover or protection of weed or rock. Relying on contour alone for their defence, the naked limpets withstand the full force of the waves.

The shield of the shell is held in position by the limpet's foot. This is a muscular disc closely applied to the rock. If taken unawares a brisk, though slight, tap removes the limpet, but if warned, the limpet can resist a pressure which Reaumur measured as thirty pounds weight. The exact operation of the mechanism is not ascertained,[2] but it is probably concerned with atmospheric pressure, or in popular language, suction.

Other molluscs, whose shells are less perfectly moulded for evasion, rely for defence on the strength of some detail of construction. Characteristic of rocky surf-swept head-

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[1] Hedley, Proc. Linn. Soc. N.S. Wales, xxxix, 1915, p. 714.

[2] Davis and Fleure, Liverpool Marine Biol. Committee, Memoir x, Patella, 1903, p. 4.

lands is the genus *Thais*, in which a large and solid shell is fortified by various devices. On the coast of New South Wales this genus is represented by a common species, *T. succincta*, which is yellow, ovate and about three inches long (fig. 19). In sheltered waters this shell has a comparatively smooth surface, but on exposed beaches it develops massive rings. So prominent are these that Chemnitz, an eighteenth century conchologist, proposed, on account of the intervening furrows, to call it the 'Cartrut' shell. Both sudden blows and steady pressure can be borne without injury by this belted armour. A related mollusc, *Drupa marginalba*, common in the rock pools, attains the same end by girdles of projecting knobs.

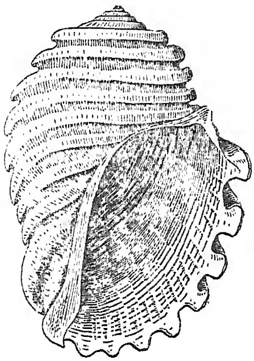

Fig. 19. *Thais succincta*, a whelk fortified by armour belts to endure the violence of the surf.

The ocean reef is as regularly differentiated into horizons, as the estuary. An upper zone between the high water of spring and neap tides is inhabited chiefly by transition amphibious forms such as the periwinkles already mentioned, *Tectarius* and *Melaraphe*, also the barnacles *Chthamalus* and *Tetraclita*. A median zone between high and low neap tides is characterised by *Galeolaria*. In a lower zone between low neap and low spring tide *Cynthia* is a dominant and typical form.

The intertidal vegetation of the ocean reef has for its most conspicuous form *Hormosira banksii*, which is rarely absent and which may develop into a dense sward, a pure formation, extending for acres (Plate II, fig. 4). It is now proposed to call such a field an "hormosiretum" and to regard it as comparable in ecological importance to the zosteretum.

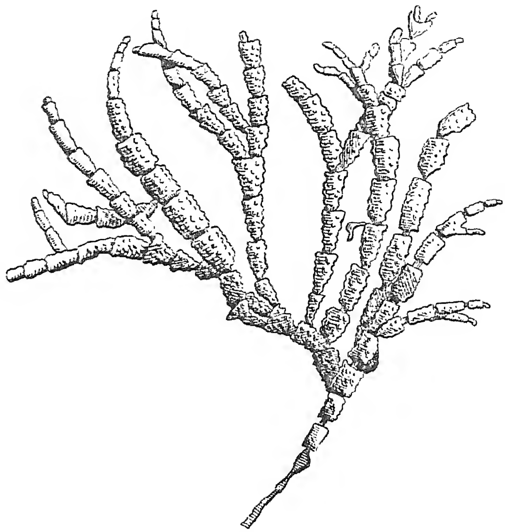

Fig. 20. *Hormosira banksii,* a characteristic plant of the ocean reef; natural size.

The *Hormosira* (fig. 20) grows in dense clusters about eight inches high. It is ochraceous in colour, and composed of tuberculate, subcylindrical joints.

At a lower level where the rocks do not dry at low water, the coralline weed, *Corallina chilensis,* (Plate III, fig. 6) forms thick moss-like tufts. It is coloured pink to bronze purple and grows a couple of inches high. The invertebrates seem not to favour it as food. When a spray is magnified (fig. 21), it appears composed of flattened heart-shaped joints something like the stem of a prickly pear.

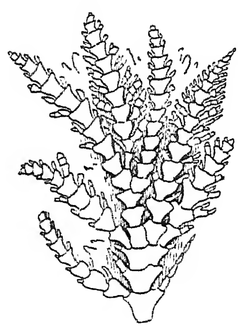

Fig. 21. *Corallina chilensis,* a moss-like plant characteristic of the lower zone of the ocean reef; magnified.

Less abundant is the Sea Cabbage, *Ulva lactuca* (fig. 22), a soft thin translucent green sea-weed which grows in small tufts, three or four inches high (Plate III, fig. 5). This is used as bait for fish, and is also readily eaten by mollusca. The *Ulva* is a tender plant, and is often killed and bleached when a hot sun coincides with a low tide. Its range is world wide,

Fig. 22. The Sea Cabbage *Ulva lactuca*, natural size, from near Mrs. Macquarie's Chair.

locally it occurs at intervals from exposed positions, such as the outer North Head to sheltered water at Mrs. Macquarie's Chair.

At the lowest intertidal horizon commence the brown sea-weeds, *Eklonia*, *Sargassum* and *Cystophora*, which correspond to the Laminarian zone of Europe. The water here is too warm for the giant kelp, so conspicuous and abundant in Tasmania and south New Zealand. Its place is taken by a dwarf kelp, *Eklonia radiata* var. *exasperata* (fig. 23). For the identification of this and other algæ I am indebted to the kindness of Mr. A. H. S. Lucas. The *Eklonia* is secured to the rocks by spreading digitate rootlets arising from a long rope-like stalk. This stem flattens above expanding to a blade whence spring large thin lobed leaves, whose surface is closely wrinkled, and whose margin is beset with thorn-shaped processes. This

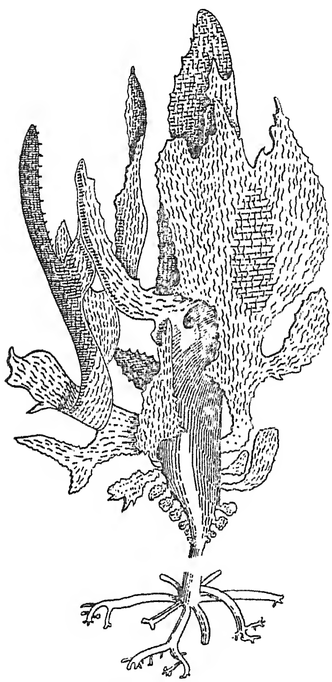

Fig. 23. *Eklonia radiata* var. *exasperata*, the dwarf kelp, a plant about a yard high, characteristic of a zone below low tide level.

plant marks the level of constant submergence; on floating pontoons where the range of the tide is artificially abolished, the dwarf kelp is attached just below the surface. After a gale the dwarf kelp wrenched off the rocks by the storm, is stacked in piles on the beaches. The chemical composition of *Eklonia exasperata* was studied by C. J. White.[1] The *Eklonia* is orange-brown in colour, and contrasts with the more yellow *Sargassum* with which it associates.

The latter genus is represented on this coast by about twenty species, one of which, *S. tristichum* (fig. 24) from Balmoral Beach is here illustrated.

A regular transition from wealth to poverty of seaweeds occurs as an observer travels from temperate to tropical beaches. In the latitude of Sydney there is still a considerable development, as is shown by the luxuriance of the *Hormosira* (Plate II, fig. 4) on the flat near Long Reef.

It was suggested, but the idea was not convincing, that the dearth of the sea-weeds in the tropics, was due to the heat of the sun scorching the vegetation at low tide. Recent bacteriological research offers another explanation. A marine bacillus, *Pseudomonas calcis*, abundant both in the mud and surface water of West Indian seas, was discovered by Drew[2] to have the curious property of abstracting nitrogen from sea water. It is probable that this or similar species have a wide distribution in tropical seas and reach Australia. So that starvation by denitrifying organisms may cause that poverty in sea weeds of tropical beaches on which several observers have remarked.

The upper zone of the ocean reef is bare of visible vegetation. Climbing higher than its fellows *Tectarius* (fig. 4)

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[1] White, this Journal, xli, 1907, p. 95.

[2] G. H. Drew, Publication No. 182, Carnegie Institution of Washington, 1914, pp. 7–45; Kellerman and Smith, Journ. Washington Academy of Sciences, iv, 1914, pp. 400–402.

fails to reach the lichen patches marking the advance limit of the terrestrial world. Between this lowest life of the

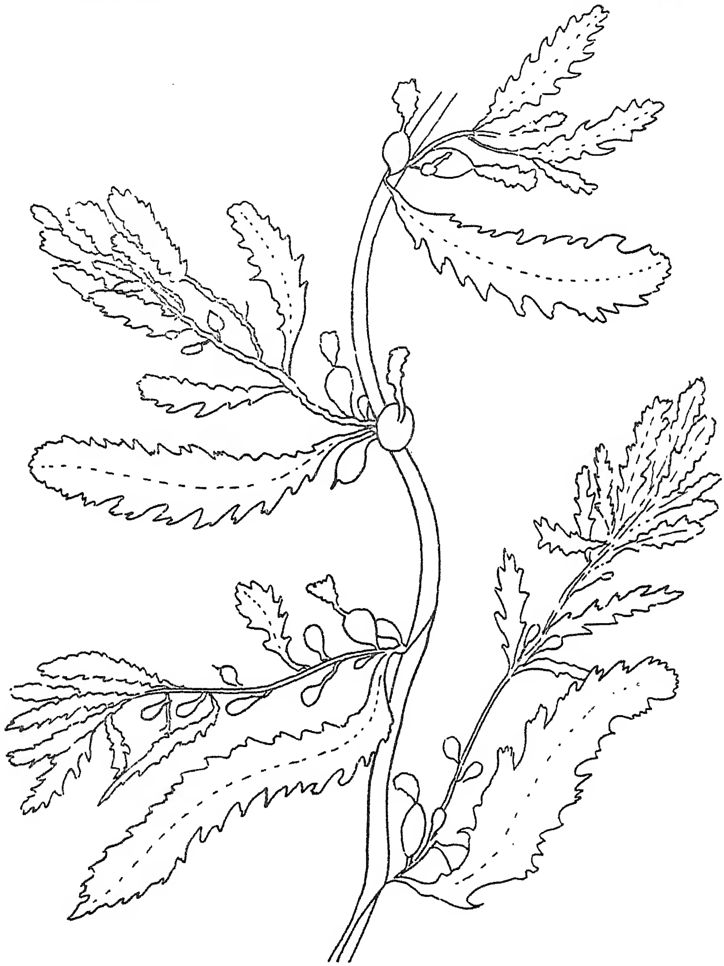

Fig. 24. *Sargassum tristichum*, a brown sea weed about a foot high, associated with *Eklonia*.

land and highest of the sea, a fairly wide vacant space here intervenes. During neap tides in hot weather the highest small rock pools evaporate and their basins are lined with

crusts of salt. Such pools, when reduced by evaporation to strong brine, may yet swarm with mosquito larvæ. At other times the rock hollows are filled with rain water, and when this happens the *Melaraphe* escape from them to dry ground.

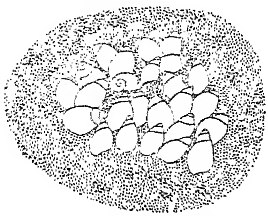

Fig. 25. Young of *Melaraphe mauritiana*, packed together at high tide level on the ocean reef.

When half, or a quarter grown the *Melaraphe mauritiana* huddle together (fig. 25) in companies of a score or more, packed as closely as possible; as adult, it is either solitary or grouped by twos or threes. In the lower part of the *Melaraphe* zone appears the barnacle, *Chthamalus antennatus* (fig. 26) a small white, solid, elevated cone with six walls and half an inch in diameter. A little lower down this is joined by another barnacle, *Tetraclita purpurascens* (fig. 27), depressed, purple, with thread like radiating riblets and with four plates to its shell which is about three-quarters of an inch in diameter. In the English Channel the barnacles harbour minute Rhabdocoele worms[1] not yet detected here.

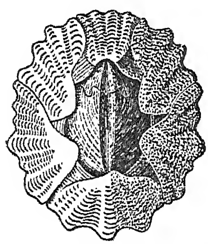

Fig: 26. *Chthamalus antennatus*, enlarged, a common barnacle from high tide level on the ocean reef.

The fellowship between periwinkle and barnacle on the upper beach zone is so intimate, that on the far-away coast of Scotland, where *Littorina* sits beside *Balanus*, it still persists.[2]

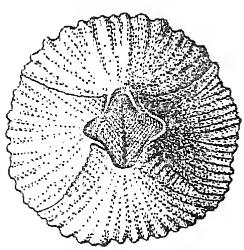

Fig. 27. *Tetraclita purpurascens*, a common barnacle associated with *Chthamalus*.

[1] Gamble, Journ. Mar. Biol. Assoc., iii, 1893. p. 31.

[2] King and Russel, Proc. Roy. Phys. Soc., Edin., xvii, 1909, p. 236.

A corresponding fauna was described from the "Zone émergée" of the Mediterranean by Prof. Marion.[1] By independence of the water these barnacles have gone far on the way to exchange a marine life for a terrestrial one, but further advance is prevented by the sessile habit.

No carnivora occur among the molluscs of this upper zone. Only *Tectarius* and *Melaraphe* can endure both absence of water, and the full blaze of the sunshine. But where constant shade is obtainable, as in a cave or under a leaning, or a south facing rock, then some barnacles and *Acmaea septiformis* climb about as high above the sea. Indeed the occurrence of barnacles in such a situation has been misconstrued as proof of a slight recent elevation of the land.[2]

Roaming over the rocks in search of food is a common and most active crab, *Leptograpsus variegatus* (fig. 28),

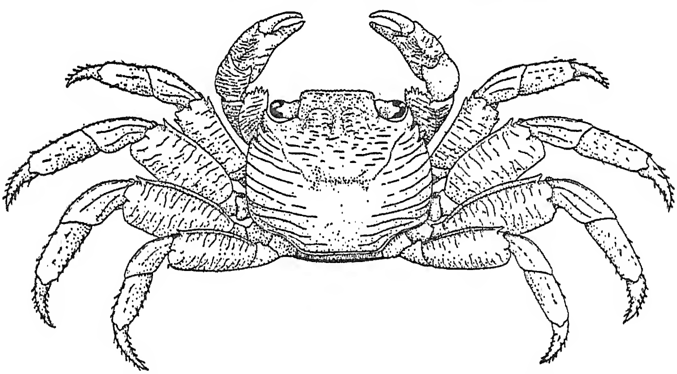

Fig. 28. *Leptograpsus variegatus*, a crab characteristic of the upper zone of the ocean reef.

equally at its ease in or out of the sea. Usually it ranges along the edge of the water, following the rising or falling

[1] Marion, Ann. Mus. Marseille, i, 1883, p. 41.

[2] Andrews, Introduction to the Physical Geography of New South Wales, 1909, p. 93.

tide. It has a smooth, square, compressed carapace about two inches broad and painted with transverse bars of white and red. Another common crab of about the same size is *Plagusia chabrus* (fig. 29), which has the limbs and body bristling with sharp thorns.

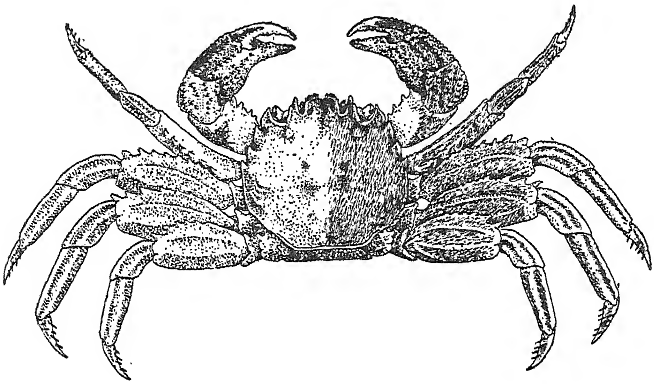

Fig. 29. *Plagusia chabrus,* a common crab.

The shells of those molluscs which are habitually exposed are extremely solid. For instance *Monodonta* which lives high on the beach has a far thicker shell than its relation *Calliostoma* which lives entirely submerged. Among naked molluscs *Onchidium*, which leaves the water, has a thicker cuticle than the Nudibranchs which never come into the air.

Below the *Melaraphe* zone the fauna rapidly increases. The limpet, *Helcioniscus variegatus*, appears accompanied by abundant gasteropoda: *Nerita melanotragus*, *Monodonta zebra*, *Drupa marginalba* and *Bembicium melanastoma; Sypharochiton pellisserpentis* represents another molluscan division, the Polyplacophora.

Dominant in the mid-tidal zone is the gregarious annelid, *Galeolaria cæspitosa.*[1] The tube of this is small, white,

[1] Bush, Harriman Alaska Expedition, xii, 1904, p. 177. Haswell, Proc. Linn. Soc. N.S.W., ix, 1885, p. 665, pl. 31, fig. 5, pl. 32, fig. 1, 2.

very solid and keeled, the keel projecting as a spur over the orifice (fig. 30). When the tide falls, the animal shrinks far down and blocks the opening by a thick lid, thus enduring long exposure to dry air and hot sun. But beneath the water, the worms are bold and active, under the microscope the branchiæ project as coiled wreaths, while to the naked eye, the waving plumes lend to the mass of stone a coat of fur (fig. 31). There is an odd local tradition that *Galeolaria* is not indigenous here, but was introduced from abroad many years ago. Perhaps this refers to some periodic fluctuation of rarity and abundance.

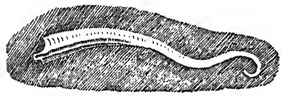

Fig. 30. Tube of the reef-building annelid worm, *Galeolaria cæspitosa*, natural size.

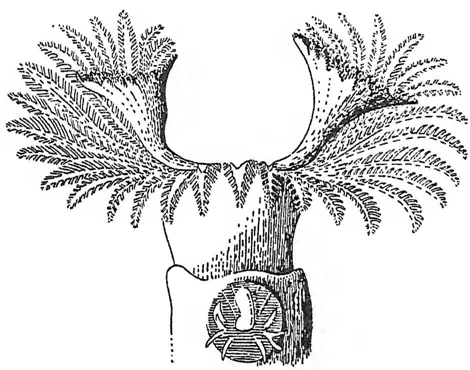

Fig. 31. *Galeolaria cæspitosa*, extruded from its tube with the branchiæ unfurled, magnified.

The *Galeolaria* is intolerant of sand or mud, its limit is the range of the neap tides, and it occurs both on the surf-swept headlands and on the wharf piles in sheltered water. In places a mass of intertwined shells forms a crust upon the rocks, six or eight inches thick. So continuous is it that the rocks appear from a distance as if painted white. Such a crust slightly resembles coral in its flowing contours, but rough surface; it deepens and narrows the original cracks and pools among the rocks. An example of such development selected for illustration is Wyargine Point at the south entrance to Middle Harbour. (Plate V, fig. 9).

A hillside clothed with timber affords food and shelter to numerous animals and plants, especially invertebrata and cryptogams, all of which would vanish if the trees were cut down. Similarly the *Galeolaria* reef shelters in its nooks and crannies a whole fauna which would disappear if the annelids were destroyed. Among the tubes there hide a host of feeble folk, such as colonies of *Lasaea australis*, a bivalve the size of a pea, *Acmaea mufria*, a tiny limpet and *Acanthochitona retrojecta*, a small chiton. In a borrowed serpulid tube, Prof. Haswell discovered a queer little crustacean, *Eisothistos vermiformis*, accommodated to its narrow abode by the assumption of a worm-like form.[1]

There are, densely crowded together, a series of larger organisms, sessile, crawling and swimming which harbour in the pools sheltered by the *Galeolaria*. From the gutter shown in the photograph I drew out these two starfish from a dark corner. *Asterina calcar* (fig. 32), a common species about four inches in diameter, has a cake-shaped body with eight short blunt rays. The disc is mottled with various shades of black, chocolate, orange, green and purple.[2] Related species which are also common in this locality are *A. exigua* with five rays, and *A. gunni* with six.

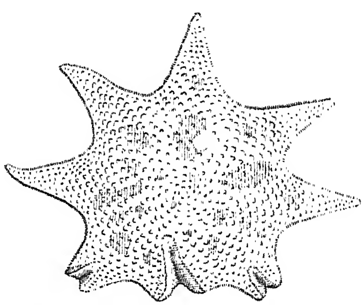

Fig. 32. *Asterina calcar,* a common starfish.

Contrasting with the neat and compact *Asterina* is the limp sprawling *Coscinasterina calamaria*[3] (fig. 33). This

[1] Haswell, Proc. Linn, Soc. N.S. Wales, ix, 1885, p. 676, pl. 36, 37.

[2] Kent, Naturalist in Australia, 1897, p. 243, pl. viii, figs. 1 - 6.

[3] H. L. Clark, Mem. Austr. Mus., iv, 1909, p. 531.

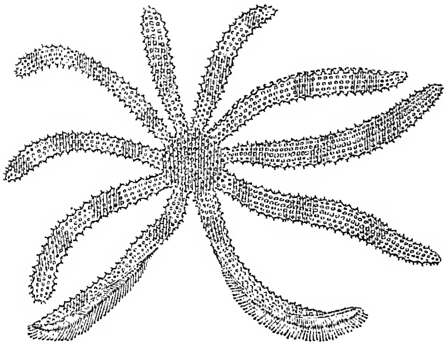

Fig. 33. *Coscinasterina calamaria*, another common starfish.

is irregular in the length and number of its finger-shaped limbs, it is coloured with sepia and sage green in patches and outlined by a margin of vivid orange red. Local starfish are not regarded as a pest by oyster cultivators as are those of European Seas.[1]

Neighbours of these are a dark-purple urchin with dense, short, fluted spines, *Toxocidaris erythrogrammus*,[2] which carves, each for itself, a cup in the stone (Plate VII, fig. 11) like that in which the European *Strongylocentrotus lividus* entrenches itself.[3] Sometimes this urchin is concealed under scraps of shells or stones held over it like shields by the pedicellariæ. Several large gasteropods such as *Thais succinta*, *Charonia rubicunda*, *Cymatium spengleri*, *Turbo stamineus* and *Haliotis naevosa*, share such retreats.

Along the edge of this gutter in the *Galeolaria* reef and exposed at low water is the sea-anemone, *Oulactis muscosa*[4] (fig. 34) which prefers a crack into which it can withdraw when disturbed. It enjoys the fullest exposure to the light and expands to a diameter of three inches. Though a fine species for this latitude, it is a pigmy compared to the giant anemones on the Great Barrier Reef, which have a spread of two feet. The trunk of the *Oulactis* is beset with

[1] Schiemenz, Journ. Mar. Biol. Assoc., iv, 1896, p. 266.

[2] Mortensen, Danish Ingolf Expedition, iv, pt. 1, 1903, p. 139.

[3] Joubin, Bull. Mus. Oceanogr. Monaco, 71, 1906, p. 19, fig. 18.

[4] Andres, Faun. Flor. Gulf Napl., ix, 1884, p. 291.

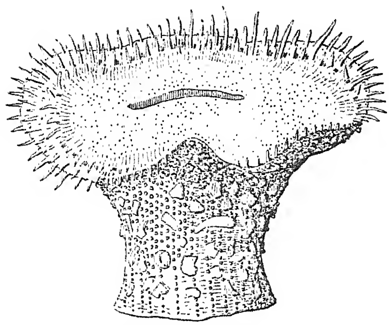

Fig. 34. *Oulactis muscosa*, a sea anemone from the ocean reef, in exposed positions, natural size.

papillæ, small and distant below; large, dense and branched above. Fragments of stone and shell adhering to these papillæ, clothe the column in an almost continuous coat. The disk is chocolate-brown, the tentacles articulated black and white, or buff and green, and the stem dark green.

There is another common anemone which is opposite to the *Oulactis* in its tastes. It occurs at a higher zone than its fellow and choses dark corners or the under sides of rocks; the stem is smooth and unclothed. Compared by its sponser to a poppy, *Paractis papaver*[1] (fig. 35) might have

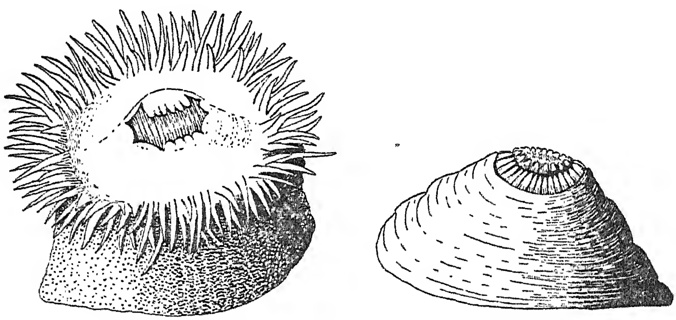

Fig. 35. *Paractis papaver*, the sea-waratah, from sheltered positions on the ocean reef.

been more aptly likened to a Waratah. For it is a uniform bright crimson except a peripheral row of blue beads.

[1] Dana, U.S. Expl. Exped., vii, 1846, Zoophytes, p. 143, pl. iv, fig. 29. *Actinia tenebrosa*, Farquhar, Journ. Linn. Soc., xxvii, 1898, p. 535, from New Zealand, seems identical.

There are several series of tentacles which when outstretched have a spread of nearly two inches.

From the side of the pool, blossoms another and very attractive annelid, *Spirographis australiensis.* In expansion the branchial whorls of this resemble a full head of thistle-down, but at the least alarm the shy creature folds up and sinks down a large membranous tube. An unexpected tenant of the rock pool is the sea spider, *Desis marina*, which constructs a diving bell of silk to contain a sufficient supply of air, and so lives in a rock crevice between tide-marks. This is one of the few animals on our beach that can be called retrograde, in the sense of having migrated from land to sea.

Underlying the zone of *Galeolaria* is that of *Cynthia*, another master organism. This association is less extensive only in the line of constant foam does it flourish, and where the surf ceases to beat upon the shore, there *Cynthia* disappears. Downwards it extends into the dwarf-kelp zone, and above it contends with *Galeolaria* for the possession of a borderland which each may alternately occupy.

Probably this giant ascidian, *Cynthia præputialis*[1] (fig. 36), is an element in our fauna of southern origin. Indeed it seems to be a generalisation of some magnitude, that the organisms of the surf are chiefly Peronian while those of the estuary have a Solanderian tone.[2] The individual tunicates form columns about six inches high and two broad, their thick tough husks are grey in colour, and usually are hidden by a growth of algæ. On the cupped summit is a double cone of the inhalent and exhalent orifices, which, opening under water, form a crimson cross, and from which above water little jets squirt. Sometimes individuals grow apart, but ordinarily they are so densely packed together

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[1] Herdman, Descrip. Cat. Tunicata, Austr. Mus., 1899, p. 27.

[2] Hedley, Proc. Linn. Soc. N.S. Wales, xxviii, 1903 (1904), p. 880.

as to overspread the rocks with a cushion which may extend for yards without a gap. (Plate IV, fig. 7.)

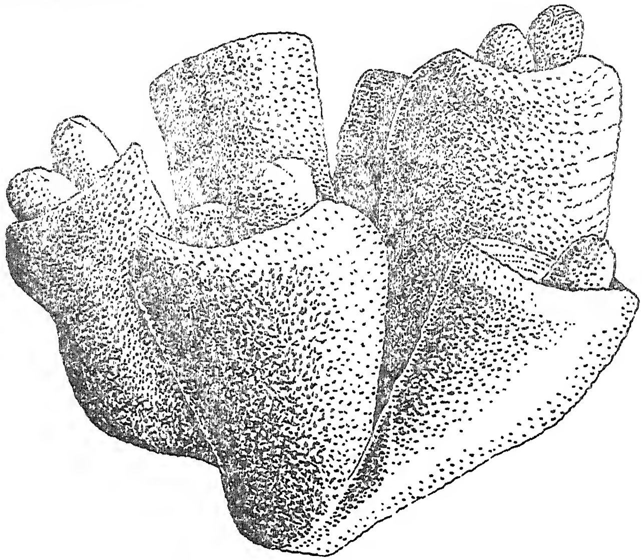

Fig. 36. A mass of cunjevoi, *Cynthia præputialis*, from low water on the ocean reef.

Fishermen scoop the viscera from the leathery envelope for bait, but the colonies so stript from the rocks are soon renewed. The fisherman's name for it, "cunjevoi," probably represents one of the few words of the local aboriginal language which still survives.

Cynthia is a patrician of beach society, whose strength and organisation protect a company of weaker plebian dependents. Between the stout firm trunks are many dark safe crevices which make pleasant homes for worms, crustacea, mollusca and such like crytozoic fauna.

In this zone there occurs, though rarely, small patches of reef-coral, *Plesiastrea urvillei*, which appears like green moss when seen alive at the bottom of a pool. It is interesting as being the furthest outlier of tropical reef corals.

The Basking Blenny, *Lepidoblennius haplodactylus* (fig. 37), about four inches long, hops actively over the weed

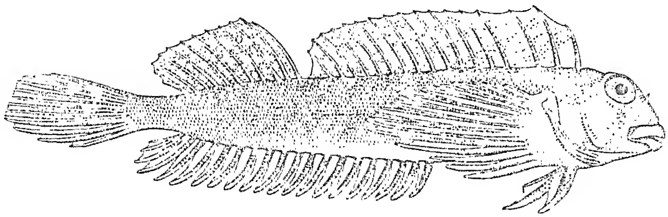

Fig. 37. *Lepidoblennius haplodactylus*, the Basking Blenny from the coralline zone of the ocean reef.

and rocks as the tide falls, and especially delights to bask in the warm sun. It remains out of water for a long time without inconvenience, clinging to the weed by curious finger-like processes into which the lower portion of the fins have developed. So correctly does the Blenny render both the colour and the pattern of the Coralline that scale, limb and trunk vanish against the harmonious background directly the fish squats down.

At low spring tides a confused tangle of dwarf kelp, *Eklonia* (fig. 23), is just exposed. This pliant mass of fronds so break and deaden the force of the waves as to provide shelter in a zone otherwise uninhabitable. The effect of the giant kelp in softening the force of great ocean waves has often been remarked.[1]

As tall unbranched saplings struggle upwards in the forest, so *Boltenia australis* (fig. 38) rises on a slender, wrinkled stalk among the dwarf kelp. And when a winter gale tears the weed from the rocks and flings it ashore the *Boltenia* shares its fate. The red and orange head and long stalk of this ascidian recalls a budding tulip of some earthly garden. A small bivalve, *Modiola*, burrows in the test, and a large orange-coloured Nemertine worm also

[1] Carmichael, Trans. Linn. Soc., xii, 1817, p. 494.

infests it, while the exterior is encrusted with a sponge, perhaps a species of *Halisarca*.

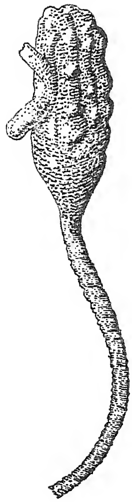

Fig. 38. *Boltenia australis*, natural size. The sea-tulip from the Eklonia zone of the ocean reef.

The *Eklonia* zone is most difficult to explore and its fauna is therefore yet imperfectly known. Besides the species that adhere to the ground there is a considerable fauna living on the stems or leaves of the plants themselves. A handsome, nacreous shell, *Cantharidus eximius*, is called the Kelp-shell, because of its exclusive resort. In contour it differs from its relations that live on the stones, for it is moulded in easy curves that the water cannot grip, and so it sits ever afloat on the swaying bands of kelp. An olive-green isopod, *Amphoroidea australiensis*, never swims, though structurally well fitted for that exercise, but clings tenaciously to the stalks of *Phyllospora comosa*. Another isopod which crawls about on the weed is *Idotea peronii* with a long body like a millepede.[1] This epiphytic fauna is considerable and would be a profitable field for study. It might be expected that this fauna would travel far on drifted weed, but I have no evidence that it does so.

Mr. T. Whitelegge, who carefully examined the *Eklonia* zone at Maroubra, has kindly given me the following notes. Two sponges of industrial possibilities, *Euspongia illawarra*, and *E. zimmocea*, occur alive under rock ledges at low tide. Attached to the roots of sea-weeds or to ascidians are the bryozoa, *Amathia tortuosa*, *Ascopodaria fruticosa*, *Cryptozoon wilsoni*, and *C. contretum*. Among the Alcyonaria

[1] Whitelegge, Rec. Austr. Mus., iii, 1899. p. 156.

there is *Cornularia australis*, a pretty little species with creeping rhizome and obconical polyps about half an inch long. The rare *Acanthoisis flabellum* was obtained alive at Maroubra.

A notable zoophyte is *Ceratella fusca*, long known from the dried skeleton only, and which was found under rock ledges at the south end of Marouba Bay, in association with *Clathrozoon wilsoni*.[1] In similar situation occurred *Thuiaria sinuosa*, *Aglaophenia sinuosa* and *A. macrocarpa*.

There is a small fish, *Iso rhothophilus*, which is only seen in the boil of the surf. For this reason, a related species is poetically known to the Japanese as the "Flower of the Wave."[2]

Following the rocks inwards from the surf to the shelter of the harbour, a gradual transition is seen in the composition of the fauna. Though *Monodonta* and *Bembicium* persist as far as the rocks go, *Helcioniscus*, *Nerita* and other forms vanish. This is partly due to decrease of salinity but chiefly to the presence of mud. The most salient feature is the rise of *Ostrea* from sporadic occurrence to the rank of a dominant organism.

The rock oyster, *Ostrea cucullata*, is ubiquitous, ranging horizontally from the surf-swept extremity of the ocean reef to the inmost recesses of the mangrove forest; vertically from mean tide level to a depth of several fathoms, and in station from rocks and mangrove roots to mud banks and zostera flats. No other constituent of the beach fauna exhibits such plasticity of form, such adaptability to different positions, such endurance of extremes of temperature or of salinity and from shelter to exposure. In the surf the shell is small, very solid, much crumpled, dentate, and

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[1] Spencer, Trans. Roy. Soc. Vict., ii, 1891, p. 123; 1892, p. 8, pl. 23.

[2] Waite, Rec. Austr. Mus., v, 1904, p. 234, pl. 25, fig. 2.

uniform purple, but in shelter it becomes thinner, larger, smoother, feebly denticulate and coloured with radial stripes of purple-black and buff. Since it extends north to Japan, but fails to reach Tasmania, it is evidently of tropical origin.

In the surf it is scattered and single, but in the estuary it packs together in a continuous reef. (Plate IV, fig. 8). Saville Kent has illustrated the far greater masses, four or five feet thick, built by this species in Moreton Bay and Port Curtis.[1] He draws attention to the fact that the zone of most luxuriant development coincides with half tide mark. Probably it spawns most freely in the saltest water, but grows quicker and larger in water of less salinity. Since the fresh water, that reduces the salinity, carries with it abundance of food material from the land, it may be thus not preferable in itself, but endured for the sake of the accompanying advantages.

Those oysters that lie on the mud, are apt to suffer from the invasion of a small worm, *Leucodore ciliatus*. To protect itself from this commensal, the mollusc excludes the worm by a partition wall, a process which, if repeated, brings exhaustion and destruction.[2]

In the vicinity of Sydney the oyster zone is followed on the lower side by a dense growth of mussels, *Brachyodontes hirsutus*, matted together in a felt of epidermis and byssus. Indeed on the estuarine rocks, *Ostrea* and *Brachyodontes* hold positions corresponding to that of *Galeolaria* and *Cynthia* on the ocean beach.

Mussel beds never form so important a feature in our beach scenery as they sometimes do abroad, as for instance on the coast of Normandy.[3] But on the Tasmanian beaches

[1] Kent, Great Barrier Reef, 1893, p. 254, pls. 39, 40; Naturalist in Australia, 1897, p. 249, pl. 42.

[2] Whitelegge, Rec. Austr. Mus., i, 1890, p. 41.

[3] Guerin, Bull. Mus. Oceanograph, Monaco 67, 1906, p. 14, pl. 1.

the rocks may be, sometimes, blackened by a thick crust of the small mussel, *Modiola pulex.*

In concluding this account of the Ecology of Sydney beaches, let me express a hope, that brief, disconnected, and superficial though it be, yet may it serve as an invitation to the pursuit of this fascinating study.

EXPLANATION OF PLATES.

Plate I, Fig. 1.

A Mangrove forest in Upper Lane Cove, seen from without at high spring tide. The lower branches of the *Avicennia* are here dipped deep in the water.

Plate I, Fig. 2.

Another mangrove forest, at Sugar-loaf Creek, Middle Harbour, seen from within at low spring tide. Here the water has retreated out of sight. A gleam of sunshine penetrates the dense shade and illuminates a thick crop of pneumatophores in the foreground. The *Avicennia* trunk in the middle of the picture is about two feet in diameter.

Plate II, Fig. 3.

General view of the zosteretum at Roseville Reserve near the head of Middle Harbour, seen at low spring tide, In the foreground, the leaves of *Zostera nana* are awash, beyond, they are exposed dry over an area of several acres. Towards the houseboat in the distance is an expanse of bare mud, on which some *Avicennia* seedlings have grown knee high. Here is a *Pyrazus-Holœcius* zone. On the opposite shore along the water's edge are more mangroves.

Plate II, Fig. 4.

A field of *Hormosira banksii,* Decaisne, seen at low spring tide from Long Reef, looking north towards Collaroy Beach. In the foreground the individual plants of the hormosiretum may be easily distinguished.

PLATE III, FIG. 5.

A rock shelf at low spring tide near Port Hacking Point. In the foreground tufts of Sea Cabbage, *Ulva lactuca*, Linn., interspersed with small pools. In the distance a breaking ocean roller.

PLATE III, FIG. 6.

An ocean reef beach at the entrance of Long Bay at low spring tide, showing the coralline weed, *Corallina chilensis*, Decaisne, exposed in the foreground. The rocks at the back, which are covered at high tide, are over-grown by limpets and barnacles.

PLATE IV, FIG. 7.

Another ocean-reef beach scene at low spring tide, from Port Hacking Point. In the foreground, a colony of *Cynthia præputialis*, Heller, a dominant form in the surf horizon. On the left, a few stragglers grow apart, but on the right, the ascidians are compacted into a continuous mass. The rock above is thickly studded with barnacles, conspicuous among which are *Balanus nigresens*, *Tetraclita rosea*, *Catophragmus polymerus*, and the mollusc *Siphonaria virgulata*. The whole range of the tide is here exposed.

PLATE IV, FIG. 8.

From Sugar Loaf Bay, Middle Harbour, the tide is here about a quarter flood. A streak of oysters *(O. cucullata*, Born.) a dominant form on estuarine rocks, plasters the rock-wall extending at a uniform level from the foreground to beyond the boat. They cluster, not only on the rock but on each other; in the immediate foreground, the uppermost tier have lost their lid or upper valve, and the empty lower valve is left adherent to the wall. Below the oysters, the usual underlining of mussels, *Brachyodontes hirsutus*, is concealed under water.

PLATE V, FIG. 9.

A rock reef at Wyargine Point, Middle Harbour, within reach of the ocean waves, seen at low neap tide. No stone is visible, though pools and fissures shadow the main features of the rocks

that underlie a continuous crust of *Galeolaria cæspitosa*, Lamk. This is a dominant form in the mid-tidal horizon of the ocean rock beach. Masses of the annelid tubes have built a cornice overhanging the pool, and in rolls, knobs, and pillows it chokes the fissure in the foreground. In fluent outline this growth recalls that of a coral reef in the surf. A few patches of stunted *Hormosira* occur on the left.

Plate V, Fig. 10.

A colony of limpets, *Helcioniscus variegatus*, perched on a smooth bare sheet of rock, exposed to heavy surf at Long Reef, near mean tide level. These have neither weed nor rock to shelter them, but depend for safety on resistant form.

Plate VI.

The beach bank of Deewhy Lagoon seen at low water; on the horizon is Long Reef. The outflow in the middle distance is now closed by a sand-beach built across by the ocean surf. Through this a stream in flood time will break a channel. The main body of the lagoon extends to the left for a considerable distance.

Photographed by Mr. J. Degotardi and published by the kind permission of the Director General of Public Works.

Plate VII, Fig. 11.

Toxocidaris erythrogrammus, the commonest rock urchin near Sydney, sunk in self-dug pits in sandstone. On the right is a vacant room.

Plate VII, Fig. 12.

A company of the Sydney Whelk, *Pyrazus herculeus*, Martyn, crawling on the bare mud-flat. This place is situated in the middle distance of Plate II, fig. 3.

A NOTE ON THE OCCURRENCE OF UREASE IN LEGUME NODULES AND OTHER PLANT PARTS.

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(Communicated by Mr. F. B. GUTHRIE.)

[*Read before the Royal Society of N. S. Wales, June 2, 1915.*]

A series of tests undertaken with the view of seeing whether the occurrence of an urea splitting enzyme in legume nodules was universal or not, has resulted in the detection of its presence in nodules of the following plants:

Trifolium minus, Relhan.
Pisum arvense, L. (Field Pea)
Glycine clandestina, Wendl.
Acacia suaveolens, Lindl. (a Sydney Wattle).
Acacia decurrens, Willd. (a Wattle)
Vicia desciacarpus.
Lathyrus latifolius, L.
Cytisus proliferus, L. fil. (Tree Lucerne)
Trifolium agrarium, L.
Vicia sativa, L.
Acacia falcata, Willd. (a Wattle)
Acacia lunata, Sieb. (a Wattle)
Acacia juniperina, Willd.
Aotus villosa, Sm.
Daviesia genistifolia, A. Cunn.
Acacia pumila, Maiden. (a Wattle)
Acacia linearis, Sims. (a Wattle)

I was unable to detect the enzyme in nodules of the following plants:

Medicago sativa, L. (Lucerne)
Medicago maculata, Willd. (Spotted Medick)
Medicago denticulata, Willd. (Clover Burr)
Trifolium repens, L. (White Clover)

The inquiry was then extended to seeds and other parts of plants. Among a number of seeds examined, seeds of the following plants gave a reaction for the presence of the enzyme.

Cucumis melo, L. (Rock Melon)

Cucurbita moschata, Duchesne (Cattle Pumpkin)

Abrus precatorius, L., very active. (Crab's Eye)

Other plant parts which were found to give a reaction for urease were:—

Ovules and pollen of a *Hippeastrum*.

The tubercles, rootlets and bulb of *Macrozamia spiralis*, Miq.

Dried immature leaves of a *Wistaria*. A measurement made of the activity of these showed that 1 gram of the dried leaf was capable of decomposing ·3 grams of urea in 16 hours.

Crushed dried remains of the following also reacted for the presence of the enzyme, the reaction obtained with the lichens being particularly pronounced and rapid.

A red Alga (saprophytic) from old fence.

A green Alga ,, ,,

Ramulina yemensis, a gray lichen.

Xanthoria parietina, a golden lichen.

Usnea barbata, a lichen.

Although no conclusions as to the part which this enzyme actually plays in the economy of the plant can be drawn from the above observations, the fact that it has been detected in parts in which symbiosis occurs and in other parts in which active metabolic changes are doubtless in progress, as in pollen, ovules, young leaves, etc., seems to suggest that some correllation may exist between its presence and those processes of elaboration and interchange of nutritive material which must be constantly occurring in the living plant.

I have to thank Mr. C. T. Musson who kindly helped me to collect the nodules and other plant parts, which have been examined, and who has been good enough to name the various plants, and to make suggestions for carrying on the work.

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ACACIA SEEDLINGS, Part I.

By R. H. Cambage, F.L.S.

With Plates VIII to XII.

[*Read before the Royal Society of N. S. Wales, July 7, 1915.*]

SYNOPSIS:

Sequence in the Development of Leaves.
Seeds.
Hypocotyl.
Cotyledons.
Primary Leaves.
Bipinnate Leaves.
Phyllodes.
Development of Uninerves and Plurinerves.
Twin Stems.
Transport of Seeds by Water.
Descriptions of Seedlings.

In order to study the development of the genus Acacia in Australia, numbers of seedlings of many species are being raised by me, and from an investigation of their characters it is thought that some information will be obtained which will assist in making the past history of this important genus better understood.

Australia is the home of that curious form of Wattle, which, as an adaptation to environment, has dispensed with its ancestral type of pinnate leaves, and developed a flattened or cylindrical leaf-stalk or phyllode to carry on the functions of leaves, and the seedlings show the phases of this transition occurring at the present day. A few species of phyllodineous Acacias are also found in New Caledonia,

the Indian Archipelago, and the Pacific Islands, and these closely resemble some of the species of tropical Australia.[1]

Sequence in the Development of Leaves.

As already pointed out, the usual sequence in the development of the leaves is that the cotyledons are succeeded by one simply-pinnate leaf, and this is followed by a varying number of alternate abruptly bipinnate leaves, the common petioles being mere stalks on the lower leaves, but gradually becoming more dilated on the upper ones, until at last they develop without any bipinnate leaves on their tips, and carry on the functions of ordinary leaves.[2]

From an examination of about 400 seedlings of about 60 species, the above sequence is found to be maintained in the great majority of cases, in fact only four species have been noticed so far, which show a constant divergence. The point of difference lies in the number of simply-pinnate leaves. Seedlings of the majority of species so far examined have only one pinnate leaf, immediately following the cotyledons, but in four species, about 70 examples have been found to produce an opposite pair of pinnate leaves. One seedling of *A. aneura* had an opposite pair of pinnate leaves, though this species appears to commonly have only one. In every case this pair has been succeeded by a bipinnate leaf, and except for the pinnate leaves appearing singly or in pairs, the sequence is the same in each case. In no instance has an example been found with the cotyledons immediately succeeded by a bipinnate leaf, although Lubbock records *Acacia Burkittii* as such a case.

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[1] B. Fl., Vol. II, p. 301.

[2] "A Contribution to our Knowledge of Seedlings," by Sir John Lubbock, Vol. I, p. 339, (1892).

"Dimorphic Foliage of *Acacia rubida* and Frutification during Bipinnate Stage," by R. H. Cambage, this Journal, XLVIII, p. 136, (1914).

Amongst those species which have only one pinnate leaf are the following:—

Acacia triptera, Benth.
,, *lanigera*, A. Cunn.
,, *juniperina*, Willd. (with few exceptions)
,, *armata*, R.Br.
,, *hispidula*, Willd.
,, *undulifolia*, A. Cunn.
,, *verniciflua*, A. Cunn.
,, *leprosa*, Sieb.
,, *stricta*, Willd.
,, *falcata*, Willd.
,, *penninervis*, Sieb.
,, *neriifolia*, A. Cunn.
,, *accola*, Maiden and Betche
,, *pycnantha*, Benth.
,, *obtusata*, Sieb.
,, *rubida*, A. Cunn.
,, *amœna*, Wendl.
,, *suaveolens*, Willd.
,, *linifolia*, Willd.
,, *fimbriata*, A. Cunn.
,, *prominens*, A. Cunn.
,, *buxifolia*, A. Cunn.
,, *podalyriœfolia*, A.C.

Acacia vestita, Ker.
,, *pravissima*, F.v.M.
,, *elongata*, Sieb.
,, *Dawsoni*, R.T. Baker
,, *pendula*, A.Cunn.
,, *stenophylla*, A. Cunn. (with an exception)
,, *melanoxylon*, R. Br.
,, *implexa*, Benth.
,, *binervata*, DC.
,, *alpina*, F.v.M.
,, *longifolia*, Willd.
,, *floribunda*, Willd.
,, *phlebophylla*, F.v.M.
,, *linearis*, Sims.
,, *Maideni*, F.v.M.
,, *pityoides*, F.v.M.
,, *aneura*, F.v.M. (with an exception)
,, *torulosa*, Benth.
,, *glaucescens*, Willd.
,, *Cunninghamii*, Hook.
,, *aulacocarpa*, A. Cunn. (with some exceptions)
,, *holosericea*, A. Cunn.

BIPINNATÆ:—*A. elata*, A. Cunn., *A. pruinosa*, A. Cunn., *A. spectabilis*, A. Cunn., *A. discolor*, Willd., *A. decurrens*, Willd., *A. Baileyana*, F.v.M., *A. dealbata*, Link., *A. leptoclada*, A. Cunn., *A. pubescens*, R.Br., *A. Bidwilli*, Benth., (only one examined).

Lubbock records five species with only one pinnate leaf, viz.:—*A. verticillata*, Sieb., *A. dodoneœfolia*, Willd., *A.*

lophantha, Willd., (regarded as an Albizzia by Bentham), *A. acanthocarpa*, Willd., and *A. dealbata.*

The four species so far noticed which constantly have an opposite pair of simply-pinnate leaves are:—UNINERVES—Racemosæ: *A. leiophylla*, Benth., *A. salicina*, Lindl., var. *varians*, and var. *Wayæ*, Maiden, *A. myrtifolia*, Willd.

BIPINNATÆ—Gummiferæ: *A. Farnesiana*, Willd.

This feature was first noticed on seedlings of *A. Farnesiana* and next on those of *A. myrtifolia.* As the former is the only Acacia known to occur in Africa, Asia and America as well as Australia, and the latter is one of the most widely spread in Australia, it was considered that possibly these are among the older forms and that the more recent species have lost one pinnate leaf. Prompted by the assumption that the widely spread species are the oldest, which of course is by no means a certainty, and that those with a pair of simply-pinnate leaves are in some way connected with such a group, an effort was made to procure seeds of *A. salicina*, another widely spread species recorded from all the States of the mainland of Australia. Seeds of the type were not obtainable, but some of the variety *Wayæ*, grown at the Sydney Botanic Gardens, were obtained from Mr. J. H. Maiden, and later those of the variety *varians* were forwarded by Mr. H. C. Cullen from near Barcaldine in Queensland. Both of these varieties produced seedlings with the opposite pair of pinnate leaves, and subsequently the feature has been noticed on seedlings of *A. leiophylla*, a West Australian species, with a more restricted range. Probably other examples may be found later.

If those species with only one pinnate leaf have been developed from an older type with two pinnate leaves, then it seems reasonable to expect that the newer form will

sometimes revert to the original or ancestral type. Possibly the above quoted example of *A. aneura* is such an instance.

The point is certainly an interesting one, and as the present work of examining seedlings proceeds, information may be obtained which will admit of a more definite conclusion being arrived at in regard to the relative ages of those species with one, and those with a pair of simply-pinnate leaves. It has already been noticed in the case of *A. leiophylla* that although the pair of pinnate leaves appear at the same time, they are of unequal size, as though in some way one has an ascendancy over the other, but in the course of a week or two they become almost equal. In the other three species mentioned the pinnate leaves of each pair are equal in size from the time they first appear.

Seeds.

Acacia seeds vary in shape, size and colour. In shape they may be compressed-globular, orbicular, ovate, obovate, ovoid, ovate-oblong, obovate-oblong, oval-oblong, oblong, and flat. In size they range at least from 3 mm. long by nearly 2 mm. broad, as in the case of *A. holosericea*, and up to a diameter of 1·1 cm. in the case of the flat seed of *A. Bidwilli.*

The method adopted in raising seedlings has been to place the seeds in a cup which is then filled with boiling water and left for about two hours. The seeds are then placed in pots and covered with about half an inch of light soil.

The oldest seeds used so far were eight years old, being those of *A. leprosa*, but it is well known that Acacia seeds will germinate after fifty years, and Professor Ewart of Melbourne records having in two instances, germinated Acacia seeds sixty-seven and sixty-eight years old.[1] In

[1] "On the Longevity of Seeds," by Prof. Alfred J. Ewart, D.SC., PH.D., F.L.S., Proc. Roy. Soc. Victoria, XXI, (N.S.) pt. 1, 1908.

my own garden, seedlings of *Acacia falcata* appear every year, and these are from seeds which have been in the soil for twenty-six years and upwards.

Hypocotyl.

The hypocotyl varies in colour, thickness and length. So far as observed, it is usually glabrous in this genus, but in some species the upper portion may in time become sprinkled with a few hairs, and it tapers from base to apex, generally evenly, but in some cases becoming suddenly constricted just above the soil. Its colour ranges from very pale or almost colourless, to pale green and pale pink, brown or red. Its thickness at the base is from about 1 mm. to 2 mm., and at the apex from about ·5 mm. to 1·5 mm. According to present observations its length ranges from about 1 cm. to 5·5 cm., but the total length or extent above the soil, does not appear to be constant for any species, and is largely regulated by the presence or absence of shelter, those growing in the open often being shorter than others which are sheltered, and which attain the greater length in their upward search for the light. The first portion of the plant to appear above the soil is the curved upper part of the hypocotyl and the base of the cotyledons.

Cotyledons.

The majority of Acacia cotyledons are oblong with the apex rounded, and with the outer side at first more or less convex, and the inner surface flat. Some are ovate while others are orbicular. All, so far examined, have entire margins but may be sagittate or auricled at the base, and are glabrous. The majority are sessile though a few are distinctly petiolate. As the curved upper portion of the hypocotyl straightens out it gradually pulls the cotyledons from the soil and out of the testa, the apex being the last to appear. If the seeds are not sufficiently covered with soil, they sometimes appear before the cotyledons have

emerged, and if the latter are unable to free themselves, the seedling may perhaps perish.

The majority of Acacia cotyledons first assume a vertical position, but within about a week, or less in some cases, become horizontal, and may remain on the plants from two to eight weeks or even longer. Those which remain vertical usually fall off in about eight or ten days during the summer months, but may remain longer in the winter, notably those of *A. neriifolia*, *leiophylla*, *salicina*, and *myrtifolia*. A feature of thin cotyledons is that within a day or two they become revolute, and later, often cylindrical, after which they soon fall. In some species such as, amongst others, *A. juniperina*, *armata*, *suaveolens*, *aneura* and *Dawsoni*, the cotyledons may remain on the plant until after the advent of the phyllodes.

The cotyledons of *A. stenophylla*, *Bidwilli*, and *Farnesiana* are fairly fleshy while those of *A. pendula* and *aneura* are slightly less so. The significance of the geographical distribution of the fleshy cotyledons will be discussed in a later paper after more evidence becomes available, but this form appears to be one which is able to exist in areas where the climate is subarid, or where the rainfall is confined mainly to one season of the year.

Primary Leaves.

In about 400 seedlings raised, the first leaf to appear has always been simply-pinnate. In a few cases, already referred to, there have appeared an opposite pair of such leaves. These leaves are petiolate, with stalks averaging from 3 to 5 mm. long, and which emerge from the stem at right angles to the cotyledons and very slightly above them, the first internode often measuring scarcely ·5 mm., consequently the first leaf and the cotyledons often appear to be at the same level. In the cases of *A. hispidula*, *leiophylla* and *stenophylla*, the stalks are sometimes over 1 cm. long.

In many species the primary leaf is quite glabrous, but in others the stalk, or in fewer cases the rachis, may be pilose, and the margins of the leaflets ciliate. Leaflets commonly number from two to five pairs, but the number is not constant for any species and sometimes only one pair may appear on a species which usually has two. *A. accola* may have up to eight, and *A. Bidwilli* nine pairs.

The leaflets are generally very shortly petiolate, the petiolule varying from about ·2 mm. to 1 mm. long, and they are usually opposite, but some are alternate. The terminal pair are generally opposite, and the rachis excurrent. A common shape of the leaflets is oblong-acuminate, sometimes mucronate and oblique, though they may be even cuneate.

There is considerable similarity in the venation of the leaflets of most species. First there is the midrib extending somewhat obliquely along the length of the leaflet and nearer to the upper than the lower margin. Next between the lower margin and the midrib there is, in many species, a second longitudinal vein, radiating from the base of the leaflet, and extending, in part, almost parallel to the midrib until it reaches near the lower margin about or above the centre. There is also a system of reticulating veins, but owing to the thickness of the epidermis this is often indistinct. (Fig. 1.)

The disposition of the two longitudinal veins, in many species, is suggestive of the possibility that the present form is a modification of a leaflet which was formerly triplinerved. This suggestion is supported by the triplinerved venation of the cotyledons of such species as *A. suaveolens* and *A. aneura*, but requires to be further investigated.

Out of about 400 seedlings taken from about 60 species, only two cases so far have been noticed where the third

leaf is simply-pinnate, viz., those of *A. juniperina*, (Plate VIII, No. 1), though a few others have appeared so, owing to one of the pinnæ not having developed or having fallen off. In all these cases the first leaf has been simply-pinnate, so that the generally-accepted view that the ancestors of the present Acacias had simply-pinnate leaves seems correct. This being so, it is perhaps not remarkable that the simply-pinnate leaf should sometimes reappear among the seedling foliage, and with extended search, many more examples among various species will probably be found.

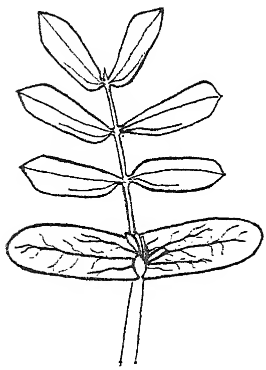

Fig. 1. *Acacia suaveolens*. Cotyledons and primary leaf. ×2.

Bipinnate Leaves.

Next after the pinnate leaf, or in some cases the opposite pair of pinnate leaves, come the bipinnate leaves, arranged alternately; the common petioles usually becoming longer for each succeeding leaf. The leaflets much resemble those of the pinnate leaf. In some instances one of the pinnæ may be broken off, or may not properly develop, and unless care be exercised in the observations, the leaf may perhaps be regarded as simply-pinnate. Often, however, some slight portion of the absent pinna or the excurrent point of the common petiole remains as evidence of the previous state of the leaf. In certain species, however, including *A. aulacocarpa*, the second and third leaves may commonly develop with only one pinna, but with the excurrent point of the petiole quite distinct, and no definite evidence of even the rudiments of the second pinna. These appear to be examples of a transition stage which will be referred to when more data are available, and should rather be

regarded as abnormal bipinnate than pinnate leaves. In a few species the pinnæ increase on some of the succeeding leaves to several pairs, and on many species each succeeding bipinnate leaf often produces an increased number of leaflets.

A well known feature in connection with many species of phyllodineous Acacias is that should the trees be cut back or wounded, bipinnate leaves will often appear, while in a few species, particularly *A. rubida* and *melanoxylon*, the older portions of a sound branch may be covered with phyllodes, while without any apparent cause, the terminal leaves of the same branch may be bipinnate, both of the above characters thereby showing a reversion to some form of ancestral foliage. The feature is perhaps more common on suckers than on plants which have grown from seedlings; though so far as observed, an Acacia sucker does not appear to ever produce a simply-pinnate leaf, but the point requires further investigation. Mr. A. A. Hamilton has recorded an instance of a tree fifteen feet high of *A. melanoxylon* producing bipinnate leaves on the tips of the phyllodes.[1] At the last monthly meeting of this Society Mr. E. Cheel exhibited a flowering specimen of *A. suaveolens* showing bipinnate foliage above the fruiting or pod-bearing twigs.

Phyllodes.

It is well known that the phyllodes are the cylindrical, dilated or vertically flattened petioles of the bipinnate leaves, and this curious development has apparently taken place in response to environment. For some reason, probably climatic, the plants evolved this form of structure as being more suitable under the existing circumstances for carrying on the functions of leaves than were the original leaves. A study of the seedlings shows that the transition from leaves to phyllodes takes place at different periods of

[1] Proc. Linn. Soc. N.S. Wales, xxxix, 1914, p. 254.

growth in different species, and also even in the same species. As already pointed out in a previous paper in this Journal (1914, p. 136), *Acacia rubida* may reach a height of ten feet, and bear flowers and fruit before any phyllodes appear, though it is the only species of phyllodineous Acacia so far recorded as doing so, while others, such as *A. Dawsoni* and *aneura*, may show considerable transition from petiole to phyllode on the second bipinnate leaf, the succeeding leaf being wholly phyllodineous, and this before the plants are more than two inches high. Others again, such as *A. salicina* var. *varians* may show the phyllode almost complete on more than a dozen bipinnate leaves, before the phyllode appears without any leaflets.

Development of Uninerves and Plurinerves.

In studying the transition from linear to dilated petioles and phyllodes, it becomes apparent that in many species of both uninerves and plurinerves one of the first indications of the change is manifested by a thickening of the nerve, partially or wholly, along or near the lower margin of the petiole, with the upper margin sometimes channelled. Next comes a vertical flattening or flange-like extension of the upper margin, with perhaps no dilation for some time on the lower margin, as though the effect of sunlight may be in some way responsible for this curious upward development. During this development the strong lower marginal nerve may be seen to retain the place of the original petiole, and is continuous from the plant stem to the base of the pinnæ. If the phyllode ultimately becomes a uninerve, then succeeding petioles show an increased amount of flange below as well as above the nerve, until at last the phyllodes appear with the nerve in about the centre of the blade, which shows obscurely a system of reticulating veins. (Fig. 3.)

The development of the plurinerved phyllode is somewhat more complex. The first indication of its advent is also a strong straight nerve along or near the lower margin of the petiole. On a succeeding petiole a convex flange-like extension is developed on the upper margin, and in this lamina a fine vein may appear approximately parallel to the lower nerve and often confluent with it at both ends.[1] A subsequent petiole may show the lamina becoming much broader on the upper side of the strong nerve, with an increased interval between the two nerves, while a lateral extension of the lamina has commenced on the lower side. If the phyllode is finally two-nerved, as in *A. verniciflua* and *binervata*, the lower nerve is usually the more prominent, and the remainder of the blade may be pinnately veined with fine lateral veins on either side of both nerves. (Fig. 2.)

When the phyllode is triplinerved, or quintuplinerved, the early development is the same as in the two-nerved types, but succeeding petioles show a lateral extension below the more prominent nerve which now appears to become the central vein, and the lower margin becomes nerve-like, or an intramarginal vein may develop on the lower side.

With a continued expansion of the blade in subsequent petioles or early phyllodes, the nerve-like margins of one phyllode sometimes seem to be represented by intramarginal veins on subsequent ones. Where the phyllodes are multinerved, the interspaces are usually finely striate with parallel veins.

Until more species are examined no conclusive opinion can be expressed as to the relative ages of the uninerves

[1] "The Development and Distribution of the Natural Order Leguminosæ," by E. C. Andrews, B.A., F.G.S., this Journal, Vol. XLVIII, p. 396, (1914).

and plurinerves, but the evidence to hand points to the uninerves as being the earlier form.

Twin Stems.

A curious feature noticed in connection with seedlings of *A. juniperina* raised from seed obtained near Professor David's residence at Woodford, is that in two separate cases one seed produced a divided hypocotyl, each portion becoming a separate stem having its pair of cotyledons, its one pinnate leaf, bipinnate leaves and phyllodes. (See Plate VIII, Nos. 3 and 4). In the case of Number 3 the bifurcation occurs just below the cotyledons, one of which is slightly higher than the other, but in Number 4, although the division first appeared at about the same position, it gradually worked down as the plant grew, until it reached the base of the hypocotyl. This appears to be the first record of twinning in the genus Acacia.

Mr. E. C. Andrews has recently found an example of twinning in a seedling near Botany Bay, apparently *A. juniperina*, and extended investigation will probably show that the feature occurs in many species.

Transport of Seeds by Water.

In connection with plant distribution over isolated areas, and the possibility of certain species being indigenous to a particular country or not, the question of transport of seeds by water has been much discussed by various writers. Where a species is found in two or more continents or on widely separated islands, theories are propounded to account for its distribution over these areas. Two of the commonest theories in regard to such dispersal are that the distribution is due either to a former land connection having existed between the two countries in question, or that seeds may have been transported by water. In certain cases the question of dispersal by wind and birds has to be carefully considered. The only Australian species of

Acacia which occurs also in America, Asia, Africa, and intervening islands, is *A. Farnesiana*, and as it seemed doubtful that its existence antedated the final separation of the great tropical lands, an experiment was made to see whether seeds of this species would retain their vitality in sea-water long enough for it to be possible for them to survive an ocean journey between these continents and islands. A pod with seeds of *Acacia Farnesiana* from Boomarra, north of Cloncurry, in tropical Queensland, was placed in a bottle of sea-water, and it sank in a few days or after the water entered the pod. Free fertile seeds of this species will sink immediately. At the end of three months the seeds were taken out, and found to be in a perfectly sound condition, and after being placed in boiling water, four were planted. In about two weeks one of the seeds germinated, producing a healthy plant. At the end of three months one of the remaining seeds was taken out of the ground, placed in boiling water and replanted. In two weeks this germinated, and produced the plant shown in Plate XII.

Seeds of the same species, collected by Sir William Cullen near Barcaldine in Central Queensland, were perfectly sound after having been left in sea-water for five months. After 146 days, two of the seeds were taken out and planted after having been placed in boiling water, and both germinated readily. At the end of 190 days another seed was taken out, and was so hard and sound that when dropped into a cup from a height of nine inches it bounced out of the cup. This seed was at once planted, after having been placed in boiling water, and germinated readily.

These experiments demonstrate that seeds of *A. Farnesiana* will retain their vitality in sea-water long enough to be transported by an ocean current for thousands of miles. It would probably be necessary however that

they should be conveyed on pieces of driftwood or pumice, for the very long distances, but anyone familiar with the sea shore well knows that every flooded river carries vast quantities of debris into the ocean, and some of this is transported by currents far from its original home.

Charles Darwin visited Cocos Keeling Islands in 1836, and collected specimens of about twenty species of plants, the whole of which he considered "must have been transported by the waves of the sea." The collection included a specimen doubtfully identified as *Acacia Farnesiana*, which species has since been definitely recorded for the Islands.[1] Darwin also quotes from Holman's Travels to the effect that amongst other things found washed up on the Islands were "immense trees, of red and white cedar, and the blue gum-wood of New Holland."[2] He subsequently carried out a series of experiments to test how long various kinds of seeds would bear immersion in sea-water without losing their vitality.[3]

In an exhaustive work on various Insular Floras of the Atlantic, Pacific and Southern Oceans, W. Botting Hemsley, F.R.S., discusses oceanic dispersal of plants and quotes Professor Ch. Martins, of Montpellier, as having germinated a seed of *Acacia julibrissin*, (*Albizzia julibrissin* according to Index Kewensis), and also of eight other species of plants, after having immersed the seeds in sea-water for ninety-three days.[4] He also quotes Alphonse De Candolle, and Gustave Thuret as considering that oceanic currents, though effective in certain cases, exercise extremely little influence in the diffusion of plants.

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[1] Journal of Researches into the Geology and Natural History of the Various Countries visited by H.M.S. Beagle, p. 541.

[2] Holman's Travels, Vol. IV, p. 378.

[3] Gardener's Chronicle, 1855, and Journ. Linn. Soc. Lond., I, p. 130.

[4] Report of the Scientific Results of the Voyage of H.M.S. Challenger, Botany, Vol. I, p. 283.

The problem has been carefully investigated over a very large area by Dr. Guppy. In speaking of the limited results obtained by testing the buoyancy in sea-water of a collection of seeds, he says that such results are sufficient, however, to illustrate the character of the sorting-process by which in the course of ages the plants with buoyant seeds or seed-vessels have been gathered at the coast. This is indicated, he writes:—

(1) "By the far greater proportion of species with buoyant seeds and seed vessels amongst the shore plants than among the inland plants.

(2) By the circumstance that almost all the seeds or fruits that float unharmed for long periods belong to shore plants.

(3) By the fact that when a genus has both inland and littoral species, the seeds or fruits of the coast species as a rule float for a long time, whilst those of the inland species either sink at once or float only for a short period."[1]

In regard to *Acacia Farnesiana* Dr. Guppy points out (p. 559) that it was introduced to the Hawaiian Islands by Europeans, and that pods of this species are now washed up on the beaches of the west coast of Oahu, one of the islands, and the seeds are to be seen germinating in numbers on the beach, the seedlings striking into the sand.

He also writes:—"The pods float unharmed in sea-water for four or five weeks, but the seeds, when freed, sink."

Dr. F. Wood-Jones mentions that many hard seeds and seed-pods are washed ashore on Cocos-Keeling Islands.[2] He also has seen a tree come ashore from some far off land, carrying quite a wheelbarrow-load of fine earth in its buttressed trunk (p. 290). He adds:—"It is certain that such a tree would have many tenants when it started on

[1] Observations of a Naturalist in the Pacific between 1896 and 1899, by H. B. Guppy, M.B., F.R.S.E., Vol. II, Plant-Dispersal, p. 22, (1906).

[2] Coral and Atolls by F. Wood-Jones, B.SC., F.Z.S., p. 171.

its voyage, and it is not unlikely that some would have the good fortune to survive the passage."

Dr. Wood-Jones tested the ocean currents at Cocos-Keeling Islands by sending adrift several sealed bottles each containing a note asking the finder to return it. After a little more than six months, a bottle was found just north of the equator, at Brava on the east coast of Africa, and the author writes :—"My little note came back again none the worse for its sea travel of over 3,000 miles." (p. 294).

The question of the original home of *Acacia Farnesiana* has been discussed by different writers[1] and must remain difficult of final solution, but from inspection of a chart showing the world's great ocean currents, it would seem possible that the species may have originated in America, from where it could have been transported by westerly currents to Australia, Asia, Africa, and intervening islands. This transportation may have been going on for many thousands of years, and great quantities of seeds perished in transit, and of those cast ashore only a small proportion may have been subsequently removed to a position suitable for growth. The period however, has been so vast during which this dispersal may have been in progress, that only the very smallest fraction of the numbers of transported seeds need have germinated in a new country for the species to have eventually become established therein.

Descriptions of Seedlings.

PUNGENTES—Uninerves.

ACACIA JUNIPERINA, Willd., "Prickly Wattle." Seeds from Woodford, Cheltenham, and Ulladulla. (Plate VIII, Numbers 1 to 5.)

Seeds dull-black, oval-oblong, 4 mm. long, 3 mm. broad, 2 mm. thick.

[1] B. Fl. Vol. II, p. 420.

Hypocotyl erect, terete, at first pale, later becoming brown, sometimes tinged with red, from 1 to 2 cm. long, 1 to 1·7 mm. thick at base, ·5 to 1 mm. at apex, glabrous.

Cotyledons two, sometimes three, and in the case of twin stems there are four, sessile, sagittate, oblong to ovate-oblong, at first erect but becoming horizontal in a few days, sometimes becoming revolute, 4 to 5 mm. long, 2 to 3 mm. broad, underside pale and stippled with brown towards apex or sometimes wholly brownish-red to dark red, usually with a raised line along centre, upperside green, glabrous.

Stem terete, pubescent, brown: first internode ·5 mm. long; second 1 mm. to 1 cm.; third 3 to 9 mm.; fourth 2 mm. to 1·2 cm.; fifth 1·5 to 6 mm.; differing in length in different individuals.

Leaves—No. 1. Abruptly pinnate, petiole 5 to 7 mm. long, glabrous; leaflets one to two pairs, obovate-oblong, acuminate, mucronate, 5 to 7 mm. long. 1 to 3 mm. broad, upperside green, underside paler, midrib fairly distinct especially in dried specimens, second nerve seen under lens, glabrous; rachis excurrent; stipules 1 to 2 mm. long, tapering to a fine point.

No. 2. Abruptly bipinnate, petiole 7 mm. to 1·2 cm. long, slightly channelled above, glabrous, excurrent; leaflets two pairs similar to those of the pinnate leaf but often smaller, glabrous; rachis 4 to 5 mm. long, glabrous, excurrent; stipules 2 mm. long. In one natural seedling from near Botany Bay, the second leaf was simply-pinnate.

No. 3. Usually abruptly bipinnate, but in two specimens, pinnate, petiole 8 mm. to 1·1 cm. long, glabrous, excurrent; leaflets two pairs, sometimes obovate; in two cases the leaflets were wanting and in their places were two spines; stipules spinescent, 3 mm. long, 1 mm. broad at base, sometimes sprinkled with white hairs.

Nos. 4, 5, 6 and 7, may be abruptly bipinnate, with one or two pairs of leaflets or they may be leafless pungent pointed phyllodes. In some cases numbers 5 and 6 may be phyllodes and No. 7 bipinnate.

No. 8 and upwards. Pungent pointed phyllodes.

UNINERVES—Armatæ.

ACACIA ARMATA, R. Br., "Kangaroo Thorn." Seeds from Mount Ainslie, Canberra. (Plate VIII, Numbers 6 to 8.)

Seeds black, oblong, 4 mm. long, 2 mm. broad, 1·5 mm. thick.

Hypocotyl erect, terete, pale green, about 1·5 cm. long, 1 mm. thick at base, about ·8 mm. at apex, glabrous.

Cotyledons sessile, sagittate, oblong, apex rounded, at first erect, but becoming horizontal in a few days, 5 mm. long, 2 mm. broad; outer or underside yellowish to pale green, with one or two parallel ridges along central portion; inner or upperside dark green, glabrous; usually remaining until after phyllodes appear.

Stem terete, pilose to pubescent, green; first internode ·5 mm. long; second 2 to 3 mm.; third 5 mm. to 1 cm.; fourth 5 to 7 mm.; differing in length in different individuals.

Leaves—No. 1. Abruptly pinnate, petiole 4 mm. long, green, glabrous; leaflets three to four pairs, ovate acuminate, often mucronate, 4 mm. long, 2 mm. broad, pale green on both sides, oblique midrib sometimes seen without lens, second vein showing under lens; rachis 4 to 6 mm. long, glabrous, excurrent, stipules slender 1 to 2 mm. long.

No. 2. Abruptly bipinnate, petiole 8 to 9 mm. long, pilose, excurrent; leaflets two to three pairs, not strictly opposite, margins sometimes brownish-red, and with scattered hairs; rachis faintly pilose, excurrent; stipules straight, slender 1 to 2 mm. long.

Nos. 3 and 4. Abruptly bipinnate, petiole often vertically flattened, 1 cm. long, and up to 1 mm. broad, pilose; leaflets two to three pairs, with scattered hairs which are more numerous towards margins, midrib fairly distinct; rachis pilose, excurrent; stipules straight, slender 2 to 3 mm. long.

No. 5. Abruptly bipinnate, petiole more dilated than in Nos. 3 and 4, and with a strong nerve extending just below the centre, from base to apex, pilose to hispid; leaflets up to four pairs.

Nos. 6, 7 and 8. Usually reduced to obliquely pungent-pointed phyllodes, lanceolate, tapering towards the base, pilose, with a fairly prominent oblique midrib, and often with a second shorter and finer vein above, the two being confluent at the base, the margins hairy; stipules slender but becoming spinescent, 4 mm. long.

UNINERVES—Brevifoliæ.

ACACIA UNDULIFOLIA, A. Cunn. Seeds from Yerranderie. (Plate VIII, Numbers 9 to 12.)

Seeds black, oval-oblong, 5 mm. long, 3 mm. broad, 1 mm. thick.

Hypocotyl erect, terete, pale red, about 2 cm. long, 1·5 to 2 mm. thick at base, 1 mm. at apex, swelling largely into the root, glabrous.

Cotyledons sessile, sagittate, oblong, apex rounded, at first erect, but soon becoming horizontal, revolute and cylindrical, falling early, 5 to 6 mm. long, 2 to 3 mm. broad; outer or underside light brownish-red, having 1 to 3 ridges along central portion; upperside pale, becoming green, glabrous; margins nerve-like, reddish.

Stem terete, pubescent; first internode ·5 mm.; second 1 to 2 mm.; third and fourth 2 to 4 mm.; fifth 3 to 4 mm.; sixth 4 to 5 mm.; seventh 5 to 6 mm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 3 mm. pale green, becoming dark green, glabrous or slightly pilose; leaflets four to five pairs, oblong, acuminate, 3 to 4 mm. long, 1·5 to 2 mm. broad, at first reddish, becoming green, midrib showing under lens; rachis 5 to 6 mm. long, glabrous, excurrent; stipules almost reduced to scales, about 1 mm. long, glabrous.

No. 2. Abruptly bipinnate, petiole about 8 mm. long, hispid; leaflets four pairs, a little broader than those of the first leaf, margins ciliate; rachis 8 to 9 mm., pilose, excurrent; scales indistinct.

No. 3. Bipinnate, petiole 1 to 1·4 cm., hispid to pubescent, excurrent; leaflets four to five pairs, margins ciliate, the pinna sometimes unequally pinnate; rachis pilose, excurrent; scales pubescent.

Nos. 4 and 5. Bipinnate, petiole about 1·5 cm. long, becoming channelled above or vertically flattened, in the latter case with a strong nerve along the lower margin, pubescent; leaflets five to eight pairs, pilose, margins ciliate, the pinna sometimes unequally pinnate; rachis hispid, excurrent: scales pubescent.

No. 6. Bipinnate, petiole pubescent, vertically flattened and showing a prominent nerve either along the centre, or in the earlier stages near the lower margin of the young phyllode, fairly straight, and connecting with the base of the pinnæ, the upper margin convex; rachis hispid to pubescent, excurrent; scales pubescent.

No. 7. Bipinnate or sometimes reduced to an obovate phyllode, 1·7 to 2 cm. long, 7 mm. broad, with distinct central nerve, and nerve-like margins, and indistinct lateral veins, mucronate, hispid to pubescent.

Nos. 8 and upwards. Usually phyllodes.

UNINERVES—Angustifoliæ.

ACACIA VERNICIFLUA, A. Cunn. Seeds from Yerranderie. Growing on Permo-Carboniferous sandstone and shale. (Plate IX, Numbers 1 to 4.)

Seeds black, oblong, 3·5 to 4 mm. long, about 1·8 to 2 mm. broad, 1 mm. thick.

Hypocotyl erect, terete, pale green, about 1·3 to 2·5 cm. long, 1 to 1·5 mm. thick at base, about ·7 to ·9 mm. at apex, glabrous.

Cotyledons sessile, sagittate, oblong, apex rounded, about 5 mm. long, 1·5 to 2·2 mm. broad, at first erect but becoming horizontal within two or three days, outer or underside at first greenish yellow, becoming green in about a week, with one or two raised nerves from base along central portion, inner or upperside yellowish-green, becoming dark green in one week, glabrous; sometimes remaining until the phyllodes are present.

Stem terete, green, glabrous, or with a few scattered hairs; first internode ·5 mm.; second 2 to 3 mm.; third 3 to 7 mm.; fourth 5 mm. to 1 cm.

Leaves—No. 1. Abruptly pinnate, petiole about 4 mm., green, glabrous; leaflets two to three pairs, oblong, acuminate, 3 to 5 mm. long, 1·5 to 2 mm. broad, green above, underside paler, oblique midrib showing under lens; rachis 3 to 4 mm. long, green, glabrous, excurrent; stipules minute.

No. 2. Abruptly bipinnate, petiole 6 to 9 mm. long, sometimes with a strong nerve along the lower edge, green, glabrous or with a few scattered hairs, excurrent; leaflets two to three pairs, the terminal pairs opposite, the remainder sometimes alternate; rachis 3 to 6 mm. long, glabrous, excurrent; stipules reduced to scales 1 mm. long.

No. 3. Abruptly bipinnate, petiole about 1 cm. long, with a few scattered hairs, usually slightly flattened vertically,

with a strong nerve along the lower edge and sometimes decurrent on the stem; leaflets three to four pairs; stipules as in No. 2.

No. 4. Sometimes reduced to a phyllode, or abruptly bipinnate with petiole from 1·5 to 2 cm. long, 2 mm. broad, with strong central nerve running to the base of the pinnæ, and a finer almost parallel nerve above, confluent with the lower one at the base; leaflets four to five pairs, oblong to obovate-oblong.

Fig. 2. *Acacia verniciflua.* Showing strong nerve on petiole of bipinnate leaf. Nat. size.

No. 5. Phyllodes from 2·5 to 3·5 cm. long and up to 1 cm. broad, lanceolate-elliptical, two-nerved, the lower one being the more prominent, and each having a system of lateral anastomosing veins, glabrous, not viscid, as in the succeeding forms.

UNINERVES—Angustifoliæ.

ACACIA LEPROSA, Sieb. Seeds from Healesville, Victoria. (Plate IX, Numbers 5 to 7.)

Seeds black, oblong, 3·5 to 4 mm. long, 2 mm. broad, 1·3 mm. thick.

Hypocotyl erect, terete, reddish-green, 1 to 1·6 cm. long, 1·3 mm. thick at base, 1 mm. at apex, glabrous.

Cotyledons sessile, sagittate, oblong, apex rounded, 5 mm. long, 2 mm. broad, at first erect but becoming horizontal in a few days and later revolute, outer or underside pale green, later becoming brown, with one or two raised lines along central portion, margins reddish-brown to peuce, inner or upperside dark green, glabrous; usually remaining until the phyllodes are present.

Stem terete or very slightly angular, pilose to pubescent; first internode ·5 mm.; second 1 mm.; third 4 mm. to 1 cm.; fourth 1·3 to 1·5 cm., varying in length in different individuals.

Leaves—No. 1. Abruptly pinnate, petiole 5 to 6 mm. long, reddish-green, becoming green, excurrent, glabrous; leaflets two to three pairs, oblong, ovate-oblong or obovate-oblong, 5 to 6 mm. long, 3 mm. broad, upperside green, underside paler, margins sometimes reddish, oblique midrib fairly distinct, second vein showing under pocket lens, glabrous; rachis 3 to 7 mm. long, glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole 8 mm. to 1·3 cm. long, pilose, excurrent; leaflets three to four pairs, usually obovate, margins red with a few scattered hairs; rachis 6 to 9 mm. long, faintly pilose, excurrent; stipules reduced to scales.

No. 3. Abruptly bipinnate, petiole 1·7 to 2·2 cm. long, pilose, usually slightly flattened vertically, sometimes with nerve showing between the lower margin and the centre, excurrent; leaflets four to five pairs, with scattered hairs on underside, and around the margins; rachis pilose, excurrent; stipules reduced to scales and soon disappearing.

No. 4. Abruptly bipinnate, petiole 2 to 2·3 cm. long, pilose to hirsute, vertically flattened, and showing a distinct nerve which is on the lower edge of the narrowed petioles, and along the centre of the broader or older ones, and sometimes decurrent on the stem; leaflets usually five pairs, sprinkled with hairs on the underside and along the margins, excurrent; rachis pilose, excurrent.

No. 5. Phyllode with central nerve and reticulating veins, tomentose when first appearing, and finally sprinkled with short hairs which are denser towards the base.

UNINERVES—RACEMOSÆ.

ACACIA SUAVEOLENS, Willd. "Sweet-scented Wattle." Seeds from Ulladulla, growing on Permo-Carboniferous sandstone. (Plate IX, Numbers 8 to 10.)

Seeds black, oblong, 6 to 7 mm. long, 3 mm. broad, 2 mm. thick.

Hypocotyl erect, terete, pale pink, about 1 to 4 cm. long, 1·3 or rarely 2 mm. thick at base, 1 mm. at apex, glabrous.

Cotyledons sessile, oblong, apex rounded, sagittate, 7 to 8 mm. long, 3 to 3·5 mm. broad, at first erect, but becoming horizontal in a few days, and usually remaining until the phyllodes are present, outer or underside deep red, and showing distinctly, especially when dry, a raised central nerve, and a shorter almost parallel vein on each side thereof, the cotyledon being triplinerved and also having numerous reticulating and anastomosing veins, inner or upperside at first greenish-brown, becoming reddish-green and finally green, glabrous. (Fig. 1.)

Stem terete in the lower portion, angular above owing to the presence of decurrent leaf-stalks, brownish-green, or sometimes glaucous. First internode ·5 mm.; second ·5 mm.; third 1 mm.; fourth 1 mm.; fifth 2 to 3 mm., varying in length in different individuals.

Leaves—No. 1. Abruptly pinnate, petiole 4 to 8 mm. long, glabrous; leaflets three to four pairs, oblong to obovate-oblong, shortly acuminate, often mucronate, 5 to 7 mm. long, 2 to 3·5 mm. broad, the basal pair usually smaller, underside red or reddish-green, becoming pale green, central nerve distinct, second nerve and reticulating veins showing under lens, upperside reddish-green, becoming light green; rachis 8 mm. to 1·2 cm. long, glabrous, excurrent; stipules reduced to scales and soon falling.

No. 2. Abruptly bipinnate, pinna lyrate, petiole 1 to 1·6 cm. long, glabrous, excurrent; leaflets three to four pairs, pale green; rachis 1 to 1·3 cm. long, glabrous, excurrent; stipules reduced to scales.

No. 3. Abruptly bipinnate, pinna usually lyrate, petiole 2 to 2·7 cm. long, glabrous, excurrent; leaflets four pairs, obovate, two-veined; stipules reduced to scales.

No. 4. Abruptly bipinnate, pinna usually lyrate, petiole 2·7 to 3·1 cm. long; leaflets four to five pairs; stipules reduced to scales 1·5 mm. long.

No. 5. Abruptly bipinnate, pinna lyrate, petiole 3 to 4 cm. long, slightly flattened vertically, with nerve along lower margin; leaflets six pairs, the terminal pair sometimes each 1 cm. long, and 7 mm. broad.

No. 6. Abruptly bipinnate, petiole vertically flattened, 3 to 4 cm. long, and up to 2 mm. broad, with a prominent nerve partially or wholly along the lower margin from the stem to the base of the pinnæ, and decurrent on the stem, the upper margin nerve-like; leaflets six to seven pairs, the basal pair very small; stipules reduced to scales 1·5 mm. long.

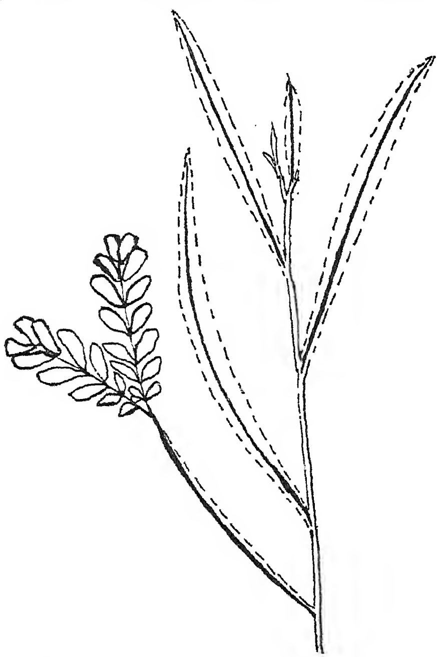

Fig. 3. *Acacia suaveolens*, showing development of nerve in phyllodes. Nat. size.

No. 7. Usually a phyllode, linear lanceolate, 5 to 7 cm. long with a distinct midrib and nerve-like margins.

UNINERVES—Racemosæ.

ACACIA PROMINENS, A. Cunn. Seeds from Gosford—(J. H. Maiden). Growing on sandy soil. (Plate X, Numbers 1 to 4.)

Seeds black, obovate, 4·5 to 5 mm. long, 3·5 mm. broad, 2·5 mm. thick.

Hypocotyl erect, terete, pale brown to reddish-brown, 1·7 to 2 cm. long, 1·3 to 1·5 mm. thick at base, about 1 mm. at apex, glabrous.

Cotyledons sessile, obovate, slightly sagittate, 5 mm. long, 3 mm. broad, at first erect, becoming horizontal and revolute in a few days, and later cylindrical, falling off in a few weeks; outer or underside reddish-brown with one or two raised longitudinal lines; upperside dark green, glabrous.

Stem terete, at first reddish-brown with a few scattered hairs, later pubescent; first internode ·5 mm., second 2 to 5 mm.; third 2 to 4 mm.; fourth and fifth 4 to 5 mm.

Leaves—No. 1. Abruptly pinnate, and showing before the cotyledons are two days old, petiole about 5 mm. long, reddish-brown, with a few scattered hairs; leaflets four to six pairs, oblong acuminate, sometimes mucronate, 5 to 8 mm. long, 1 to 2 mm. broad, upperside green, underside at first red, becoming pale green; rachis 7 mm. to 1·5 cm. long, brownish-green, usually glabrous or with a few scattered hairs.

No. 2. Abruptly bipinnate, petiole about 1 cm. long, at first pilose, often becoming pubescent, excurrent; leaflets four to six pairs, upperside green, paler underneath.

No. 3. Abruptly bipinnate, petiole 1 to 1·4 cm. long, at first pilose, becoming pubescent, slightly channelled above, usually with a prominent gland near the middle of the upper edge; leaflets six to nine pairs, upperside green,

underside reddish-green, becoming pale green; stipules green, oblong, acuminate, 1·5 mm. long, ·5 mm. broad at base.

Nos. 4 and 5. Abruptly bipinnate, petiole similar to that of No. 2, and with prominent gland; leaflets six to eleven and rarely thirteen pairs.

Nos. 6, 7 and 8. Either abruptly bipinnate, with petiole vertically flattened to scarcely 1 mm. broad, and with a prominent central nerve; or reduced to a phyllode, elliptical, mucronate, with central nerve, sometimes running obliquely to the apex with the lower margin nerve-like for about half its length, or with central nerve merging into the lower margin at about half the distance to the apex, the phyllode pilose.

UNINERVES—Racemosæ.

ACACIA VESTITA, Ker. Seeds from Mudgee—(L.F. Harper). (Plate X, Numbers 5 to 8.)

Seeds black, obovate-oblong to oval-oblong, 5 to 6 mm. long, 3·5 to 4 mm. broad, 1·5 mm. thick.

Hypocotyl erect, terete, reddish to reddish-green, 1·7 to 3 cm. long, 2 mm. thick at base, 1 mm. at apex, glabrous, or the upper portion may become sprinkled with a few hairs.

Cotyledons sessile, very slightly auricled, overlapping the hypocotyl about 1 mm., obovate, 5 to 6 mm. long, 4 mm. broad, at first erect but becoming horizontal and revolute in a few days, cylindrical within a week, and falling in two or three weeks, outer or underside purple, usually with raised portion longitudinally along centre, upperside greyish-green, becoming green, glabrous.

Stem terete, or angular where leaf-stalks are decurrent on the stem, pubescent. First internode ·5 mm.; second 1 to 8 mm.; third 1 mm. to 1·4 cm.; fourth about 3 mm.; fifth up to 5 mm.; sixth up to 7 mm., varying in different individuals.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 5 mm. long, hispid; leaflets three to four pairs, oblong-acuminate, usually mucronate, about 5 to 7 mm. long, and nearly 2 to 2·5 mm. broad, underside reddish-green, becoming pale green, upperside light green, midrib fairly distinct, second vein showing under pocket lens; rachis 7 to 8 mm. long, pilose, excurrent; stipules small.

No. 2. Abruptly bipinnate, petiole 3 to 5 mm. long, hispid, excurrent; leaflets four to six pairs, margins sometimes ciliate; rachis pilose, excurrent; stipules 1 mm. long.

Nos. 3 and 4. Abruptly bipinnate, petiole about 6 mm. long, hispid to pubescent, excurrent; leaflets and rachis similar to those of No. 2; stipules small.

No. 5. Abruptly bipinnate, petiole slightly flattened vertically, about 6 to 7 mm. long, pubescent; leaflets six to seven pairs, margins sometimes ciliate, rachis hispid, excurrent; stipules small.

No. 6. Reduced to a phyllode or abruptly bipinnate, with dilated, hispid, falcate petiole, the tapering, hispid, excurrent point being sometimes 3 mm. long, prominent central nerve running to the base of the pinnæ on upper margin of flattened petiole; leaflets about seven pairs, rachis hispid, excurrent.

No. 7. Usually a phyllode obliquely-elliptical 6 to 8 mm. long, 4 mm. broad, hispid, upper margin almost semicircular lower margin straighter and somewhat nerve-like, central nerve curving and prominent, mucronate; lateral veins numerous but indistinct.

PLURINERVES—Oligoneuræ.

ACACIA DAWSONI, R. T. Baker. Seeds from Queanbeyan. (Plate X, Numbers 9 to 11.)

Seeds black, oblong, 3·5 to 4·5 mm. long, nearly 2 mm. broad, 1 mm. thick.

Hypocotyl erect, terete, light-brown, 1 to 1·5 cm. long, 1 mm. thick at base, ·5 mm. at apex, glabrous.

Cotyledons sessile, oblong, apex rounded, slightly sagittate, 4 mm. long, 1·5 to 1·7 mm. broad, underside pale green stippled with brown to reddish-brown, upperside at first pale green becoming dark green, glabrous.

Stem terete, glabrous. First internode ·5 mm.; second ·5 mm.; third 2 mm.; fourth 5 mm.; fifth 1 cm.

Leaves—No. 1. Abruptly pinnate, petiole 3 mm. long, glabrous; leaflets two pairs, oblong, acuminate, or obovate, 3 to 4 mm. long, 1·5 to 2 mm. broad; upperside green, underside paler, midrib and second vein showing under lens; rachis about 2 mm. long, glabrous, excurrent.

No. 2. Abruptly bipinnate, petiole 3 to 5 mm. long, usually slightly dilated, glabrous, excurrent; leaflets two pairs; rachis excurrent.

No. 3. Abruptly bipinnate, petiole 1·4 to 2 cm. long, vertically flattened and narrowed towards the base, showing two distinct veins confluent at both ends, the lower one the more prominent, glabrous; leaflets two pairs, oblique midrib fairly distinct, secondary and reticulating veins showing under pocket lens, often mucronate, green, glabrous.

Fig. 4. *Acacia Dawsoni*. About one and a half times natural size.

No. 4. A phyllode, about 3·5 cm. long, 6 mm. broad, oblong-lanceolate, narrowed at the base, glabrous with two distinct nerves confluent at both ends, the lower nerve the more prominent and direct, the lateral veins much finer and almost parallel with the main nerves, the loopings at the ends of the lateral veins forming in places a sort of intramarginal vein.

PLURINERVES—Julifloræ—Stenophyllæ.

ACACIA ANEURA, F.v.M., "Mulga." Seeds from Bourke, (J. H. Maiden). (Plate XI, Numbers 1 to 3.)

Seeds shiny dark brown, ovate, flat, about 5 mm. long, nearly 4 mm. broad, 1·5 mm. thick.

Hypocotyl erect, terete, pale green, about 3 cm. long, 1·5 mm. thick at base, 1 mm. at apex, glabrous.

Cotyledons two, rarely three, sessile, obovate-oblong, apex rounded, sagittate, 6 to 7 mm. long, 4 to 4·7 mm. broad, obscurely triplinerved and with reticulate venation seen best in dried specimens, at first erect but becoming horizontal in a few days and usually remaining on the plant until the phyllodes appear; outer or underside pale green, sometimes with raised central nerve fairly distinct, upperside dark green. On a plant with three cotyledons, one was of normal size and the other two were on the opposite side and smaller, being 5 to 6 mm. long, 2·5 to 3 mm. broad, each sagittate.

Stem terete or slightly angular where affected by decurrent leafstalks, green, thinly sprinkled with fine hairs. First internode ·5 mm.; second 1 mm.; third 4 to 5 mm.; fourth about 1 cm.

Leaves—No. 1. Abruptly pinnate, usually very slow in developing, petiole 5 to 7 mm. long, pale green, glabrous; leaflets two pairs, the petiolule sometimes 1 mm. long, obovate-oblong, often mucronate, with sometimes a few hairs on margin, 6 to 9 mm. long, 3 mm. broad, upperside green, underside paler, midrib distinct, especially in dried specimens, secondary nerve and lateral venation more obscured; rachis about 6 mm. long, pale green, glabrous, excurrent; stipules reduced to small scales. One seedling had an opposite pair of pinnate leaves, each with two pairs of leaflets.

No. 2. Bipinnate, petiole in some cases slightly dilated, about 1 cm. long, pilose, excurrent; leaflets two to three pairs, in some cases not strictly opposite, light green.

No. 3. Bipinnate, petiole sometimes vertically flattened, up to about 3 cm. long, with two distinct nerves, the more prominent one being close to the lower margin, and extending directly to the base of the pinnæ, sprinkled with fine hairs; leaflets three pairs, mucronate, margins often obscurely ciliate; rachis pilose or almost glabrous, excurrent.

No. 4. May be a narrow linear phyllode about 4·5 cm. long, 3 mm. broad, with an oblique or recurved hispid point, finely striate, but with two nerves, and especially the lower, more conspicuous than the rest, sometimes minutely hoary, and more distinctly so when first appearing.

PLURINERVES—Julifloræ—Falcatæ.

ACACIA GLAUCESCENS, Willd., "Coast Myall." Seeds from banks of Nepean River, Mulgoa. (Plate XI, Numbers 4 to 6.)

Seeds black, oblong, about 4·5 to 5 mm. long, 1·5 to 2 mm. broad, 1·5 mm. thick.

Hypocotyl erect, terete, red, from about 1·3 to 2 cm. long, 1 mm. thick at base, ·5 mm. at apex, glabrous.

Cotyledons sessile, sagittate, oblong, apex rounded, 5 to 6 mm. long, 2 mm. broad, underside red, upperside green, glabrous.

Stem terete, or slightly angular where affected by the decurrent leaf stalks, pubescent; first internode ·5 mm.; second ·5 mm.; third ·5 to 1 mm.; fourth 1 to 2 mm.; fifth 3 to 5 mm.; sixth about 1 cm.; varying in different individuals.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 3 mm. long, pilose or almost glabrous; leaflets two pairs, oblong,

acuminate, 4 to 5 mm. long, 1·5 to 2 mm. broad, upperside green, underside red, midrib fairly distinct, secondary vein showing under lens, glabrous with finely ciliate margins; rachis 2 to 3 mm. long, slightly pilose, excurrent; stipules reduced to scales.

No. 2. Abruptly bipinnate, petiole slightly dilated in some cases, from about 5 mm. to 1 cm. long, pilose to hoary, excurrent; leaflets two pairs, upperside green, underside red, margins reddish with a few scattered hairs; rachis pilose, excurrent.

No. 3. Abruptly bipinnate, petiole usually dilated, with a nerve along lower margin, pilose to hoary, excurrent; leaflets two to three pairs.

No. 4. Abruptly bipinnate, petiole vertically flattened, 1·5 to 2 cm. long, 2 mm. broad, with prominent nerve along lower margin and three or four finer veins above, pilose to hoary, excurrent; leaflets three to four pairs, upperside green, underside at first pale red, becoming green, margins slightly ciliate; rachis pilose, excurrent.

No. 5. Abruptly bipinnate, petiole vertically flattened, with prominent nerve along lower margin, and 8 or 9 finer ones above, some not extending the whole way.

No. 6. Abruptly bipinnate, petiole vertically flattened, hoary, 3·5 cm. long, 6 mm. broad, narrowed at both ends, with a prominent nerve about 2 mm. from the lower margin, and a second a little less prominent about 2 mm. above, thus dividing the petiole into three equal sections, each of which is finely striate with parallel nerves; leaflets four to five pairs; stiplues reduced to hoary scales, about 1·5 mm. long, ·5 mm. broad at base, tapering to a point.

Nos. 7, 8 and 9. Phyllodes with the two prominent nerves as in No. 6, and a third though slightly finer one about equidistant below them, the interspaces being finely striate,

while both margins are nerve-like. There appears to be some relationship between this central prominent nerve and the strong lower-marginal nerve which appears on the earliest dilated petioles. These nerves do not become confluent with the lower margin towards the base as in the case of *A. Cunninghamii.*

PLURINERVES—Julifloræ—Falcatæ.

ACACIA CUNNINGHAMII, Hook. Locally called Curracabark. Seeds from Barber's Pinnacle, Boggabri. (Plate XI, Numbers 7 to 9.)

Seeds black, oblong, about 4·5 to 5 mm. long, 1·5 to 2 mm. broad, 1·5 mm. thick.

Hypocotyl erect, terete, pale red, 1·5 to 3·6 cm. long, 1 to 1·4 mm. thick at base, ·6 to 1 mm. at apex, glabrous.

Cotyledons sessile, oblong, sagittate, 6 mm. long, 2 mm. broad, underside red, upperside green, glabrous.

Stem terete, or slightly angular where affected by the decurrent leaf-stalks, pilose to hirsute. First internode ·5 mm.; second ·5 to 3 mm.; third, fourth and fifth about 2 to 4 mm.; sixth about 1 cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 5 mm. long, green, sprinkled with a few hairs; leaflets two pairs, oblong, acuminate, 4 to 9 mm. long, 2 to 3 mm. broad, upperside green, underside red, in some cases becoming reddish-green, midrib distinct, secondary vein showing under lens, margins sometimes red with a few scattered hairs; rachis 2 to 4 mm. long, glabrous, excurrent; stipules reddish, 1 mm. long.

No. 2. Abruptly bipinnate, petiole 6 mm. to 1 cm. long, green, pilose, sometimes becoming hoary, excurrent; leaflets two pairs, upperside green, underside red, often becoming pale green, margins often red, with a few scattered hairs; rachis pale green, pilose, excurrent.

Nos. 3 and 4. Abruptly bipinnate, petiole usually slightly dilated, with distinct nerve along lower margin, pilose to hoary, excurrent; leaflets three pairs on No. 3, four pairs on No. 4; rachis green, pilose, excurrent; stipules reduced to scales.

Nos. 5 and 6. Abruptly bipinnate, petiole vertically flattened from 1·2 to 2·5 cm. long, with a prominent nerve following the base of the lower margin for about one fourth the length of petiole, and beyond this point being slightly removed from the margin, the remainder of the petiole being finely striate with parallel veins; pilose to hirsute; leaflets four pairs.

Nos. 7 and 8. Phyllodes, oblong-falcate, narrowed at both ends, with two distinct nerves, the lower one the more prominent, and becoming confluent towards the base of the lower margin with another distinct nerve which follows the lower margin from the base for a short distance beyond the point of contact with the prominent nerve.

PLURINERVES—Juliifloræ—Dimidiatæ.

ACACIA HOLOSERICEA, A. Cunn. Seeds from Croydon, North Queensland. (Plate XII, Numbers 1 to 4.)

Seeds black, oblong, 3 mm. long, nearly 2 mm. broad, 1·2 mm. thick.

Hypocotyl erect, terete, pale coloured, becoming brownish-green, from about 1·6 to 2·2 cm. long, ·8 mm. to 1·4 mm. thick at base, about ·5 to ·7 mm. at apex, glabrous.

Cotyledons sessile, oblong, sagittate, apex rounded, about 4·5 mm. long, 2 to 2·5 mm. broad, at first erect but becoming horizontal in a few days, and finally revolute, outer or underside pale green, with one or two raised lines along or near the centre, upperside green, glabrous.

Stem terete in the lower portion, but angular when affected by the decurrent nerves of the flattened petioles

and phyllodes, at first green and pilose, becoming hoary; first internode ·5 mm.; second 2 to 3 mm.; third 3 mm. to 1 cm.; fourth 5 mm. to 1 cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 3 mm. long, at first green, becoming reddish-green, glabrous; leaflets three pairs, oblong, acuminate, often mucronate, 3 to 5 mm. long, 2 to 3 mm. broad, margins often red, midrib usually distinct, second vein showing under lens, underside pale green, faintly hoary, upperside green, glabrous; rachis 4 to 5 mm. long, glabrous, excurrent; stipules minute.

No. 2. Abruptly bipinnate, petiole 6 mm. to 1 cm. long, at first green and glabrous, becoming pilose to hoary, excurrent; leaflets two to three pairs, the basal pair sometimes little more than rudimentary, oblong to obovate, underside pale green, very faintly hoary, margins often red, with a few scattered hairs; rachis glabrous, excurrent.

Nos. 3 and 4. Abruptly bipinnate, petioles up to 1 cm. long; leaflets four to five pairs.

No. 5. Abruptly bipinnate, petiole about 1 cm. long, slightly dilated, or channelled above, leaflets seven pairs; rachis 1·7 cm. long; stipules reduced to scales.

No. 6. Abruptly bipinnate, petiole 2·5 cm. long, vertically flattened, 2 mm. broad, narrowed at both ends, pilose, with a prominent nerve along the lower margin, decurrent on the stem, and connected with the base of the pinnæ, also having a fine, though distinct vein along the centre of the petiole, and confluent at both ends with the lower marginal nerve; leaflets eight pairs.

No. 7. Abruptly bipinnate, petiole 3 cm. long, vertically flattened, 6 mm. broad, narrowed at both ends, owing to the flange like broadening of the dilated petiole the prominent nerve in its central portion is slightly removed from the lower margin, but coincides with it for a short

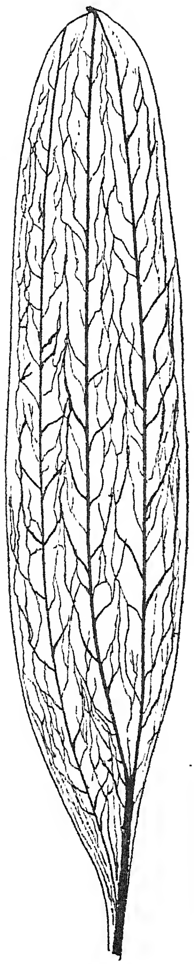

Fig. 5. *Acacia holosericea.*

Adult leaf showing convergence of three prominent veins towards lower margin. About two-thirds natural size.

distance at both ends, and extends from the base of the pinnæ to the stem where it becomes decurrent. There is also a fine nerve along the lower margin. This fine vein and the prominent nerve appear to correspond with the more prominent lower marginal nerve in No. 6. The finer though distinct central vein is scarcely confluent with the prominent nerve at either end; leaflets eight to ten pairs.

No. 8. A phyllode with two distinct nerves, equally prominent, confluent at the apex and also at the lower margin near the base, while a third slightly less distinct nerve follows on the lower margin, the whole being thinly sprinkled with short fine hairs, but very much less dense and conspicuous than the beautiful silky pubescence which appears on the usually triplinerved adult foliage.

BIPINNATÆ—Gummiferæ.

ACACIA FARNESIANA, Willd. Locally called Mimosa. Seeds from Boomarra, Cloncurry, North Queensland. (Miss K. Hillcoat.) (Plate XII, Numbers 5 and 6.)

Seeds brown, obliquely obovate, slightly concave on one side, 8 mm. long, 5 mm. broad, 4 mm. thick.

Hypocotyl erect, terete, pale coloured, 2·2 to 3·6 cm. long, 2 mm. thick at base, 1·5 mm. at apex, glabrous.

Cotyledons ovate, petiolate, auricled, at first erect, becoming horizontal in a few days and often remaining on plant for two to three months, up to 1·2 cm. long, 7 mm. to 1 cm. broad, fleshy, outer or underside at first pale yellow, becoming yellowish-green, upperside light green, glabrous; petiole 2 to 2·5 mm. long.

Stem terete, green, glabrous. First internode 1 to 5 mm.; second 8 mm. to 1·8 cm.; third 6 mm. to 1·4 cm.; fourth 7 mm. to 1·8 cm.

Leaves—Nos. 1 and 2. Abruptly pinnate, forming an opposite pair, petiole slender, from about 6 mm. to 1 cm. long, yellowish-green, glabrous; leaflets five pairs, narrow-oblong to obovate-oblong, shortly acuminate or obtuse, 3 to 7 mm. long, 1·5 to 2 mm. broad, oblique midrib fairly distinct, upperside light green, underside paler; rachis up to 2 cm. long, slender, glabrous; stipules 1·5 mm. long.

Nos. 3, 4, 5 and 6. Abruptly bipinnate, petiole slender, from about 6 mm. to 1·5 cm. long, pale green, often channelled above, glabrous, excurrent: leaflets five to seven pairs, similar to those of Nos. 1 and 2; rachis slender, up to 2·5 cm. long, excurrent; stipules converted into tender spines up to 4 mm. long.

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In all the above descriptions the measurements quoted of the various parts of the seedlings are either the average lengths or the extremes so far met with, but in some cases the variation is so considerable that it seems likely further investigation may show that the greatest extremes of length have not yet been recorded.

EXPLANATION OF PLATES.

Plate VIII.

Acacia juniperina, Willd.

1. Cotyledons, first and third leaves pinnate, second and fourth bipinnate, stipules. Ulladulla.
2. Three cotyledons and pinnate leaf. Cheltenham.
3. Twin stems from one seed, each stem with two cotyledons and one pinnate leaf, hypocotyl bifurcated just beneath cotyledons. Woodford.
4. Twin stems from one seed, cotyledons (four) dropped, hypocotyl bifurcated at base. Woodford.
5. Pod and seeds. Ulladulla.

Acacia armata, R. Br.

6. Cotyledons, pinnate leaf, bipinnate leaves, phyllodes, stipules, and root nodules. Mount Ainslie, Canberra.
7. Cotyledons, pinnate and bipinnate leaves.
8. Pod and seeds.

Acacia undulifolia, A. Cunn.

9. Pinnate leaf, bipinnate leaves and phyllodes. Yerranderie, Burragorang.

19. Revolute cotyledons and pinnate leaf.

11. Cotyledons, with pinnate leaf just showing.
12. Part of pod and seeds.

Plate IX.

Acacia verniciflua, A. Cunn.

1. Cotyledons. Yerranderie.
2. Cotyledons and pinnate leaf.
3. Pinnate leaf, bipinnate leaves and phyllodes.
4. Pod and seeds.

Acacia leprosa, Sieb.

5. Cotyledons, pinnate and young bipinnate leaves. Healesville, Victoria.
6. Cotyledons, pinnate leaf, bipinnate leaves and phyllodes.
7. Pod and seeds.

Acacia suaveolens, Willd.

8. Cotyledons and pinnate leaf. Ulladulla.
9. One cotyledon, pinnate leaf, bipinnate leaves and phyllodes.
10. Pod and seeds.

PLATE X.

Acacia prominens, A. Cunn.

1. Cotyledons with pinnate leaf showing. Gosford, (J.H.Maiden).
2. Revolute cotyledons and pinnate leaf.
3. Bipinnate leaves and phyllodes. Pinnate leaf dropped Gland showing on some of upper phyllodes.
4. Pod and seeds.

Acacia vestita, Ker.

5. Cotyledons. Mudgee, (L. F. Harper).
6. Cylindrical cotyledons and pinnate leaf.
7. Pinnate leaf, bipinnate leaves and phyllodes. Nodules on roots.
8. Part of pod and seeds.

Acacia Dawsoni, R. T. Baker.

9. Cotyledons, pinnate and bipinnate leaves. Queanbeyan.
10. Pinnate leaf, bipinnate leaves and phyllodes.
11. Pod and seeds.

PLATE XI.

Acacia aneura, F v.M.

1. Cotyledons (three), pinnate leaf and young bipinnate leaves. Bourke, (J. H. Maiden).
2. Cotyledons, pinnate leaf, bipinnate leaves and phyllodes.
3. Seeds.

Acacia glaucescens, Willd.

4. Cotyledons, pinnate leaf, and two bipinnate leaves. Mulgoa.
5. Pinnate leaf, bipinnate leaves (with one pinna broken off No. 3), and phyllodes.
6. Pod and seeds.

Acacia Cunninghamii, Hook.

7. Cotyledons and pinnate leaf. Boggabri.
8. Bipinnate leaves and phyllodes. Pinnate leaf dropped.
9 Half length of pod and seeds.

Plate XII.

Acacia holosericea, A. Cunn.

1. Cotyledons with tip of pinnate leaf showing. Croydon, North Queensland.
2. Cotyledons and pinnate leaf.
3. Pinnate leaf, bipinnate leaves and phyllodes. Nodule on root.
4. Spirally twisted pod and seeds.

Acacia Farnesiana, Willd.

5. Cotyledons, opposite pair of pinnate leaves, bipinnate leaves and stipules. Boomarra, Cloncurry, North Queensland, (Miss K. Hillcoat). The seed from which this plant grew, was left in sea-water for three months, then placed in boiling water and planted. After three months it was taken up, placed in boiling water and again planted, when it at once germinated.
6. Pod and seeds.

SOME NOTES ON *Blechnum capense*, (L.) SCHLECHT. (WITH DESCRIPTION OF VAR. *Gregsoni*, VAR. NOV.)

By Rev. W. WALTER WATTS.

[*Read before the Royal Society of N. S. Wales, July 7, 1915.*]

SPECIAL interest attaches to the fern known as *Blechnum capense*, a species having a wide tropical and subtropical range, being found in South Africa, South America, and in "the mountains of all countries and islands of the South Seas and the Malayan area" (*teste* Dr. Christ). It is well-known and widely spread in Australasia, especially on the Blue Mountains of New South Wales, in the southern districts of Australia generally, and in Tasmania and New Zealand.

Many botanists, in the nineteenth century, following Willdenow (1809), divided the ferns now included in *Blechnum* into the two genera, *Lomaria* and *Blechnum*. *Lomaria* was made to consist of blechnoid ferns having dimorphic leaves, the fruiting fronds, or their segments, being of linear form, with a marginal sorus covered by an involucre (indusium) formed of the modified and incurved margin of the leaf; *Blechnum* consisted of similar ferns in which, however, the leaves were of uniform shape, the sorus parallel with, and adnate to, the midrib, and the involucre independent of, and at a distance from, the margin. In some systems the two genera were even placed in separate tribes.

Under this classification, *Blechnum capense* appeared as *Lomaria capensis*, Willd., or *Lomaria procera*, (Forst.) Spreng.

This generic separation of *Lomaria* from *Blechnum* has been discontinued by most modern pteridologists, all the blechnoid ferns being now comprised in the genus *Blechnum;* but the divergent characters of the two forms have been recognised in the subgenera, *Lomaria* and *Eublechnum.*

Blechnum capense is invariably placed within the subgenus *Lomaria*, because its normal form shews linear fertile pinnæ, with a marginal or submarginal sorus and indusium. Dr. Christ (Farnkraütr. p. 178) describes the fertile leaf of *Lomaria procera* (i.e. *capensis*) as being narrower than the sterile, and the fertile pinna as being "4 mm. breit," which accurately enough describes the normal form. In describing the genus, *Lomaria*, however, he does not recognise the indusium as consisting of the modified margin of the leaf: it "appears almost marginal." Hooker and Baker (Synops. p. 179) describe the indusium of *Lomaria procera* as "sometimes slightly intramarginal," although, in their definition of the genus, *Lomaria*, the "involucre" is said to be "formed of the revolute edge of the frond." They thus recognise the divergence of this species from the usual lomarioid type.

Dr. F. O. Bower published, last year,[1] the results of a careful phylogenetic study of "Blechnum and Allied Genera." In this paper, Dr. Bower contends for the view that *Lomaria* and *Eublechnum* are phylogenetically inseparable. The former, with its dimorphic leaves, its marginal sori, and its indusium consisting of the modified leaf-margin, he takes to be the primitive form. *Eublechnum*, in Dr. Bower's view, shows an exactly similar formation, the intramarginal indusium being the original leaf-margin,—what he calls the "phyletic margin,"—and the expanded part of the leaf, *i.e.*, the part lying between the indusium and the ostensible margin, consisting of a "flange," which

[1] Annals of Botany, XXVIII, No. cxi, July, 1914.

is a continuation of the lateral growth of the original fertile leaf; the indusium is said to have made a "phyletic slide" in the process of development.

The bearing of Dr. Bower's investigations upon *Blechnum capense* lies in this: that this fern is of such variable form that it exhibits the characters, now of *Lomaria*, and now of *Eublechnum*. Generally, the variabilty takes such partial forms as the following: a pinna may show the normal sterile spread in its lower half, and, in its upper half, the narrow linear fructification; or, *vice versa*, the upper part of the pinna may have the normal sterile spread, and the lower part the narrow lomarioid fructification; or, again, the pinnæ on one side of a frond may be of the usual sterile form, and those on the opposite side may show the narrowed fertile character. But Dr. Bower, with a wide range of specimens before him, goes further, and says that "types are sometimes found in which the pinna appears as in *B. brasiliense*, with the linear sori close right and left of the midrib, and the flange, which is usually small in this species, widened out into a broad expansion with an extensive venation of its own" (p. 381 *loc. cit.*).

So far as our Australian specimens are concerned, the great majority of them show the normal lomarioid fruiting form, *i.e.*, exhibit typical dimorphic characters; but, in the Sydney Herbarium, there are specimens that show an undoubted eublechnoid tendency. This tendency, for the most part, appears in the irregular forms indicated by Dr. Bower,—forms in which the lomarioid fructification shares a frond with the eublechnoid sterile formation; but, now and again, specimens are found that exhibit the eublechnoid character, more or less, throughout, though, where this occurs, the fertile frond is usually much narrower than the sterile: thus preserving the typical dimorphic character.

In one specimen alone, in my experience, does the full eublechnoid character appear. It was collected, near Mount Wilson (N.S.W.) by Mr. Jesse Gregson, who, for many years, has taken a deep interest in the botany of that mountain, and has sent many good specimens to the Sydney Herbarium. Mr. Gregson's *Blechnum* was collected in 1902; and, recently, under that gentleman's direction, it was found in good quantity and in excellent condition, by Mr. J. L. Boorman, of the National Herbarium, Sydney. It is, apparently, to be found at one spot alone, where it grows on a wet ledge in the face of a perpendicular cliff overlooking a permanent creek in a gully at the base of Green Mountain, a little on the Bell side of Mount Wilson.

This fern, being entirely, or almost entirely, eublechnoid in character, I regarded, at first, as a new species: an opinion that was strengthened when I found specimens from Mr. Gregson's original collection put away, by the late Mr. Betche, as *Blechnum serrulatum*. Later, however, I found other specimens from Mr. Gregson's collection in the *Blechnum capense* box, together with a note stating that this fern had been submitted to Dr. Christ, and determined by him as an abnormal form of *B. capense.* In support of this view, two pinnæ were mounted, in which the fertile leaf-spread was contracted, in one or two places, to the lomarioid form. These pinnæ are matched in some of Mr. Boorman's specimens, and due importance must be attached to them, though they appear to me to be possibly due to some damage by insects or bruising. But fully allowing for these occasional pinna-breaks as hints of lomarioid origin, the Green Mountain specimens appear to be quite unique in their eublechnoid character. With the exception of the slight occasional breaks referred to, all the fronds are entirely eublechnoid: the fertile pinnæ have a form scarcely, if at all, distinguishable from the sterile,

while the sori are consistently juxta-costal throughout. The scales at the base of the stipes, and on the rhizome, are shorter and wider than the normal scales of *B. capense*, but this, perhaps, is not a character of large importance in a fern that exhibits such strange variability. Mr. Gregson's fern, however, being so markedly divergent from the typical *B. capense*, and representing, as it does, an extreme eublechnoid development, appears to me to demand a position as a distinct variety, which I take the liberty of dedicating to its discoverer as

Blechnum capense, (L.) Schlecht, var. *Gregsoni*, var. nov.

Frondes fertiles frondibus sterilibus simillimæ, vel cum illis uniformes; fructificatio prope vel omnino eublechnoidea; basis stipitis paleis perlatis et brevibus prædita.

THE MOSSES OF THE NEW HEBRIDES.

By Dr. V. F. Brotherus and the Rev. W. Walter Watts.

[Read before the Royal Society of N. S. Wales, July 7, 1915.]

Foreword by Rev. W. W. Watts.

Many years ago, Dr. V. F. Brotherus suggested to me that I should try to get some of my Missionary friends in the New Hebrides to collect specimens of the Moss flora of the islands. At the time I did not realise how little was known of this flora, or my efforts would have been more serious than they were. However, in response to my request, Dr. Annand, who was then in charge of the Training Institute at Tangoa, on the Island of Santo, (a position from which he recently retired, after nearly fifty years of valued service), sent me, in 1903-4, two or three small but intensely interesting parcels. In 1906, his colleague and successor, the Rev. F. G. Bowie, M.A., sent a small collection to my friend, Mr. J. R. Murdoch, of Melbourne, while, in 1909, he kindly sent to me, direct, a fine collection of rarities. About the same time, the Rev. T. E. Riddle, of Epi, (now in India), began to collect the mosses of that island, with most interesting results. A little later, I was fortunate enough to interest Dr. William Gunn, of Aneityum and Futuna, in the mosses of his district, and he has sent me several beautiful collections, exceptionally rich in new species. His first material was divided, half of it being sent to the Rev. David Lillie, of Caithness; but all the mosses dealt with in this paper, including those sent to Mr. Lillie, have been examined by Dr. Brotherus, of Helsingfors, who unites with me in expressing our great obligations to the Missionaries who have so kindly sent specimens, and our sincere hope that both Dr. Gunn and Mr. Bowie will continue their good services; and that other missionaries

on the islands will also interest themselves in a field of natural science that is bound to yield many new species, and, may be, some new genera.

It is interesting to know that Dr. Gunn has been successful in getting some of the natives to collect material. The result has been that specimens have been received from different sides of Aneityum, and from parts of Futuna difficult of access.

An interesting feature of this contribution to the knowledge of the moss flora of the New Hebrides is the evidence it affords of a close connection with the flora of the Dutch Archipelago and Papua, as well as with that of Fiji and Samoa.

Group ACROCARPI.

DICRANACEÆ.

Dicranoloma Ren.

D. brachysteleum (C.M.)

"New Hebrides": teste Broth., "Bryales," p. 322.

D. Braunii (C. M.)

Aneityum: Dr. Gunn, March, 1911 (Hb. Watts, 242, 250), Aug. 1912 (276), May-June, 1913 (347, 432: S.W. side). Previous range: Java, Sumatra, Papua.

Leucoloma Brid.

L. (Subvittata) subtenuifolium Broth. et Watts, n.sp.

Dioicum; gracilescens, cæspitosum, cæspitibus densis, pallide viridibus vel lutescentibus, nitidiusculis; *caulis* usque ad 6 cm. longus, nigrescens, densiuscule foliosus, simplex vel dichotome ramosus; *folia* faciliter decidua, patula, superiora subsecunda, comalia adpressa, caudam brevem saepe falcatulam efformantia, canaliculato-concava, e basi lanceolata longe et anguste subulata, usque ad 8 mm. longa, marginibus erectis, in parte superiore subulae minute serrulatis, limbata, limbo hyalino, basi c. 4 seriato, dein sensim angustiore, infra summum apicem subulae evanido,

nervo tenui, continuo, cellulis laminalibus minutissimis, quadratis, minutissime papillosis, subulam totam in parte lanceolata spatium tantum juxta nervum occupantibus, cellulis basilaribus ut etiam superioribus externis valde incrassatis, lumine anguste lineari, levissimis, alaribus laxis, numerosis, fuscis vel hyalinis. Caetera ignota.

Futuna: Gunn, March-April, 1910 (Hb. Lillie, 523); Aneityum: Gunn, 1911 (Hb. Lillie, 544, 694), Aug. 1912 (Hb. Watts, 271, Hb. Lillie, 728), Feb. 1913 (Hb. Watts, 344), May-June, 1913 (Hb. Watts, 407, 421).

Species *L. tenuifolio* Mitt. valde affinis, sed foliorum limbo multo angustiore dignoscenda.

Campylopus Brid.

C. introflexus (Hedw.) Mitt.

Aneityum: Gunn, March and Oct.; 1911 (Hb. Watts, 190, 224). Previous range: Southern States of North America, South Brazil, Australia, Tasmania, New Zealand.

C. species?

Aneityum: Gunn, Feb. 1913 (Hb. Watts, 355).

Dicranodontium Br. Eur.

D. species?

Futuna: Gunn, Oct. 1912 (Hb. Watts, 297).

Pilopogon Brid.

P. Blumii (Doz. et Molk.) Broth.

Aneityum: Gunn, Oct., 1911 (Hb. Watts, 191, 194). Previous range: Malesia.

DICNEMONACEÆ.

Synodontia Duby.

S. aneitensis Broth. et Watts, n.sp.

Gracilescens, cæspitosa, cæspitibus densis, rigidis, lutescentibus, nitidis; *caulis* elongatus, repens, densissime ramosus, ramis erectis, vix ultra 1 cm. longis, dense foliosis, simplicibus, obtusis; *folia*

ramea erecto-patentia, sicca erectiora, concava, e basi elliptica sensim lanceolato-acuminata, acuta, c. 2 mm. vel paulum ultra longa et c. 0·45 mm. lata, marginibus apice subconniventibus, integerrimis, enervia, cellulis elongatis, valde incrassatis, lumine angustissimo, alaribus numerosis, subquadratis, fuscis; *bracteae perichaetii* internae convolutaceae, breviter acuminatae, fere ad apicem setae productae; *seta* 1·5 cm. vel paulum ultra alta, crassa, rubra; *theca* erecta, asymmetrica, subcylindracea, strumulosa, sicca sub ore valde contracta, fusca, aetate atrofusca; *operculum* e basi conica, oblique rostratum.

Aneityum: Gunn, 1911 (Hb. Lillie, 701), Feb. 1913 (Hb. Watts, 375, 377a). Species a congeneribus adhuc cognitis longe diversa.

LEUCOBRYACEÆ.

Leucobryum Hampe.

L. *Gunnii* Broth. et Watts, n.sp.

Dioicum; gracilescens, cæspitosum, cæspitibus densis, mollibus, albescenti-glaucoviridibus, opacis; *caulis* erectus vel adscendens, usque ad 2 cm. longus, dense foliosus, dichotome ramosus; *folia* sicca et humida horride patentia, canaliculato-concava, e basi anguste ovali lineari-lanceolata, obtusiuscula, mucronata, c. 3·5 mm. longa et usque ad 0·5 mm. lata, dorso scaberrima, bistratosa, cellulis alarum pauciseriatis. Caetera ignota.

Futuna: Gunn, Oct. 1912 (Hb. Watts, 303); Aneityum: Gunn, 1913 (Hb. Watts 357c, 454a).

Species mollitie, foliisque horride patentibus, angustis, dorso scaberrimis dignoscenda.

L. *aneitense* Broth. et Watts, n.sp.

Dioicum; gracilescens, cæspitosum, cæspitibus densis, mollibus, albescentibus, opacis; *caulis* erectus vel adscendens, usque ad 3 cm. longus, dense foliosus, dichotome ramosus; *folia* patentia, sicca flexuosula, humida stricta, canaliculato-concava, e basi ovali anguste lanceolata, sensim acuminata, acuta, usque ad 5 cm. longa et 0·8 mm. lata, dorso scaberula, bistratosa, cellulis alarum pluriseriatis. Caetera ignota.

Aneityum: Gunn, 1911 (Hb. Watts, 241, 230 ex p.), 1912 (Hb. Lillie, 736). 1913 (Hb. Watts, 357a).

Species *L. Gunnii* affinis, sed foliis longioribus, siccis flexuosulis, dorso minus scabris, cellulis alarum pluriseriatis dignoscenda.

L. candidum (Brid.) Jaeg.

Futuna: Gunn, Oct. 1910 and 1912 (Hb. Watts, 203, 325); Aneityum: Gunn (Hb. Watts, several numbers); Epi, 2,000 feet; Riddle, Jan. 1911 (139).

L. conocladum Besch.; *L. uncinatulum* Broth. olim.

Aneityum: Gunn, 1911-1913 (Hb. Watts, several numbers).

L. neo-caledonicum Besch.

Futuna: Gunn (Hb. Watts, 327); Aneityum: Gunn (Hb. Watts, several numbers).

L. sanctum Hampe.

Santo: Bowie, 1909 (Hb. Watts, 41, 78 ex p.). Previous range: from Nepal to Malesia.

L. stenophyllum Besch.

Aneityum (S.W. side): Gunn, May-June, 1913 (Hb. Watts, 418).

Leucophanes Brid.

L. glauculum C.M.

Tangoa, Santo: Dr. Annand, Dec., 1903 (Hb. Watts, 15a). Previous range: Malesia.

L. octoblepharoides Brid.

Tangoa, Santo: Annand, 1903 (Hb. Watts, 4, 13, 15); Bowie, 1909 (77); Epi: Riddle, Aug. 1911, above 1,000 feet (Hb. Watts, 158); Paama: Gunn and Frater, June, 1912 (Hb. Watts, 257). Range: from Nepal to the Pacific Islands.

Octoblepharum Hedw.

O. albidum (L.) Hedw.

Santo: Bowie, 1909 (Hb. Watts, 42).

Arthrocormus Doz. et Molk.

A. Schimperi D. et M.

Tangoa, Santo: Bowie, 1906 (Hb. Watts, 61, comm. J. R. Murdoch). Previous record: The Sunda Islands.

Exodictyon Card.

E. dentatum (Mitt.) Card.

Tangoa, Santo: Bowie, 1906 (Hb. Watts, 74, comm. J. R. Murdoch), 1909 (76, 79, 80); Futuna: Gunn, Oct. 1912 (288). Previous record: Samoa.

E. subscabrum (Broth.) Card.

Santo: Bowie, 1909 (Hb. Watts, 43). Previous record: Papua.

FISSIDENTACEÆ.

Fissidens Hedw.

F. (Semilimbidium) subscabrisetus Broth. et Watts, n.sp.

Dioicus; gracilis, cæspitosus, cæspitibus densiusculis, viridissimis, opacis; *caulis* usque ad 5 mm. longus, infima basi fuscoradiculosus, dense foliosus, simplex; *folia* usque ad 15-juga, erectopatentia, infima minuta, dein multo majora, oblongo-lingulata, breviter acuminata, acuta, usque ad 1·5 mm. longa et 0·4 mm. lata, integerrima, lamina vera ad medium folii producta, inferne indistincte limbata, lamina dorsali ad basin nervi enata ibidemque rotundata, nervo flexuosulo, infra summum apicem folii evanido, cellulis minutissimis, rotundato-hexagonis, valde chlorophyllosis, papillosis; *seta* c. 1·5 mm. alta, tenuis, lutescens, scaberula; *theca* suberecta, minuta, ovalis, sicca deoperculata sub ore constricta, pallida. Caetera ignota.

Paama: Gunn and Frater, June 1912 (Hb. Watts, 255).

Species *F. scabriseto* Mitt. affinis, sed inflorescentia foliorum forma et lamina vera indistincte limbata dignoscenda.

CALYMPERACEÆ.

Syrrhopodon Schwgr.

S. albo-vaginatus Schw.

Aneityum: Gunn, 1913 (Hb. Watts, 500 ex p.).

S. (Cavifolia) Lilliei Broth., n.sp.

Dioicus; gracilis, cæspitosus, cæspitibus densis, late extensis, glauco-viridibus, opacis; caulis erectus, vix ultra 1 cm longus, inferne tomentosus, dense foliosus, simplex; *folia* sicca incurva, humida e basi brevi erecta, superne paulum latiore ibidemque serrata in laminam erecto-patentem, linearem, c. 2 mm longam, obtusam, saepe brevissime mucronatam sensim attenuata, marginibus integris, angustissime hyalino-limbatis, nervo sat tenui, subcontinuo, levi, cellulis laminalibus et basilaribus supremis minutis, subquadratis, papilla elevata, uncinata instructis, cellulis partis vaginantis marginalibus angustissimis, limbum hyalinum c. 6 seriatum efformantibus, internis laxis, teneris, quadratis vel breviter rectangularibus, inanibus. Caetera ignota.

Aneityum: Gunn, 1912 (Hb. Lillie, 740), Feb. 1913 (Hb. Watts, 350).

Species *S. gracili* Mitt. valde affinis, sed foliis obtusioribus, muticis vel brevissime mucronatis dignoscenda.

S. Muelleri (Doz. et M. as *Calymperidium*) Lac.

Santo: Bowie, 1909 (Hb. Watts, 70a). Aneityum: Gunn, Feb. 1913 (Hb. Watts, 352), May-June, on north side of Island (Hb. Watts, 412).

S. (Orthotheca) perarmatus Broth., n.sp.

Dioicus; robustiusculus, cæspitosus, cæspitibus densis, viridibus, inferne pallidis, opacis; *caulis* erectus, usque ad 7 cm. longus, parce radiculosus, dense foliosus, dichotome ramosus; *folia* e basi erecta, elongate oblonga, superne ciliato-serrata sensim in laminam patentem, usque ad 5 mm. vel paulum ultra longam, anguste linearem, obtusiusculam vel acutam attenuata, marginibus partis laminalis incrassatis, argute geminatim serratis, nervo crasso, subcontinuo, parte inferiore vaginali excepta ubique grosse aculeato, cellulis laminalibus minutis, incrassatis, lumine subquadrato, pellucidis, levibus, cellulis partis vaginalis marginalibus in seriebus paucis eisdem laminalibus similibus, internis laxis, ovali-hexagonis, inanibus; *seta* erecta, c. 5 mm. alta, tenuissima, rubra; *theca* erecta, minuta, ovalis, rufa. Caetera ignota.

Santo: Bowie, 1909 (Hb. Watts, 89); Aneityum: Gunn, Oct., 1911 (Hb. Watts; 193, Hb. Lillie, 697), May-June, 1913 (Hb. Watts, 410); Futuna: Gunn, Oct. 1912 (Hb. Watts, 292).

S. *(Orthotheca) diversiretis* Broth. et Watts, n.sp.

Dioicus; robustiusculus, cæspitosus, cæspitibus densis, viridibus, aetate lutescenti-viridibus, opacis; *caulis* erectus, usque ad 5 cm. longus, fusco-tomentosus, dense foliosus, dichotome ramosus vel simplex; *folia* e basi erecta, oblonga, superne serrata sensim in laminam erecto-patentem, usque ad 5 mm. longam, linearem, acuminatam, obtusiusculam vel acutam attenuata, marginibus partis laminalis incrassatis, superne geminatim serratis, nervo crasso, continuo vel excedente, levi, cellulis laminalibus minutis, subquadratis, pellucidis levibus, cellulis partis vaginalis superioribus eisdem laminalibus similibus, marginalibus in seriebus paucis anguste rectangularibus, internis breviter et late rectangularibus. Caetera ignota.

Aneityum: Gunn, Feb., 1913 (Hb. Watts, 352a); S.W. side, May-June, 1913 (Hb. Watts, 434).

Species a *S. perarmato* habitu subsimili foliorum structura longe diversa.

S. *(Orthotheca) aneitensis* Broth. et Watts, n.sp.

Dioicus; robustiusculus, cæspitosus, cæspitibus laxis, lutescenti-viridibus, opacis; *caulis* erectus, vix ultra 2 cm. longus, fusco-tomentosus, dense foliosus, simplex vel furcatus; *folia* e basi erecta, oblonga, superne serrata sensim in laminam erecto-patentem, usque ad 6 mm. longam, linearem, breviter acuminatam, obtusiusculam attenuata, marginibus partis laminalis incrassatis, superne geminatim serratis, nervo crasso, basi c. 0·10 mm. lato, subcontinuo, levi, cellulis laminalibus minutis, subquadratis, pellucidis, levibus, cellulis partis vaginalis superioribus eisdem laminalibus similibus, marginalibus in seriebus paucis anguste rectangularibus, internis breviter et late rectangularis. Caetera ignota.

Aneityum: Gunn, 1911 (Hb. Lillie, 688).

Species *S. diversireti* valde affinis, sed nervo subcontinuo, nunquam excedente, lamina apice latiore, ut videtur diversa.

S. (*Orthotheca*) *tenuinervis* Broth. et Watts, n.sp.

Dioicus; robustiusculus, cæspitosus, cæspitibus densis, laete viridibus, opacis; *caulis* erectus, vix ultra 1 cm. longus, fusco-tomentosus, dense foliosus, simplex; *folia* e basi erecta, oblonga, superne serrata sensim in laminam erecto-patentem, usque ad 6 mm. longam, linearem, obtusam, marginibus laminae incrassatis, superne geminatim serratis, nervo basi vix ultra 0·05 mm. lato, subcontinuo, levi, cellulis laminalibus minutis, subquadratis, levibus, cellulis partis vaginantis superioribus eisdem laminalibus similibus, marginalibus in seriebus paucis, anguste rectangularibus, internis breviter et late rectangularibus. Caetera ignota.

Futuna: Gunn, Oct., 1912 (Hb. Watts, 318).

Species *S. aneitensi* valde affinis, sed foliis latioribus, nervo multo tenuiore dignoscenda.

S. *constrictus* Sull. (*S. tubulosus* Lac.)

Santo: Annand, 1903 (Hb. Watts, 16); Bowie, 1909 (39, 92, 93, 94, 95, 96). Previous range: Great Natunas, Sumatra, Borneo, Louisiades, Sandwich Islands, Samoa, Tahiti.

S. *fasciculatus* Hook. et Grev.

Santo: Bowie, 1909 (Hb. Watts, 40, 97); Epi, 2,000 ft.: Riddle, Jan. 1911 (Hb. Watts, 143); Aneityum: Gunn, Oct. 1913 (Hb. Watts, 342, 446). Widespread in the Pacific, but not previously recorded for the New Hebrides.

S. *tristichus* Nees.

Tangoa, Santo: Bowie, 1906 (Hb. Watts, 75, comm. Murdoch); Aneityum: Gunn (Hb. Watts, several numbers). Previous range: Ceylon, Sumatra, Java, Amboina.

***Calymperidium* (See *Syrrhopodon Muelleri*).**

Calymperes Sw.

C. Angstroemii Besch.

Tangoa, Santo: Annand, Dec., 1903 (Hb. Watts, 9, 16b, 26, 27). Previous record: Tahiti.

C. lorifolium Mitt.

Aneityum, north side: Gunn, May-June, 1913 (Hb. Watts, 413).

C. serratum A. Br.

Santo: Bowie, 1909 (Hb. Watts, 70, mixed with *Syrrhopodon Muelleri*); Aneityum: Gunn, 1913 (475). Previous record: Java.

POTTIACEÆ.

Hyophila Brid.

H. microphylla Broth. et Watts, n.sp.; *Anœctangium linguæfolium* Olim.

Dioica; tenella, cæspitosa, cæspitibus densis, late extensis, viridibus, intus fuscescentibus, opacis; *caulis* erectus, vix ultra 3 mm. longus, inferne dense fusco-radiculosus, dense foliosus, simplex vel furcatus; *folia* sicca spiraliter contorta, humida erecto-patentia, lanceolato-ligulata, rotundato-obtusa, usque ad 1·2 mm. longa, inferne usque ad 0·35 mm. lata, marginibus inferne recurvis, superne erectis, integerrimis, nervo crassiusculo, infra summum apicem folii evanido vel continuo, dorso superne scabro, cellulis minutis, quadratis, verrucosis, obscuris, basilaribus majoribus, breviter rectangularibus, pellucidis, levibus. Caetera ignota.

Aneityum: Gunn, Oct., 1911 (Hb. Watts, 192, Hb. Lillie, 699); 1912 (Hb. Lillie, 741); Feb. 1913 (Hb. Watts, 353).

Species minutie foliorumque forma facillime dignoscenda.

Barbula Hedw.

B. (Hydrogonium) aneitensis Broth. et Watts, n.sp.

Dioica; gracilescens, cæspitosa, cæspitibus densis, glauco-viridibus, subopacis; *caulis* erectus vel adscendens, usque ad 5 cm. longus, inferne fusco-radiculosus, dense foliosus, dichotome

ramosus; *folia* sicca crispatula, humida patentia, concava, lanceolato-ligulata, obtusiuscula vel obtusa, c. 2 mm longa, marginibus erectis, integris vel summo apice denticulis paucis instructis, nervo crassiusculo, subcontinuo, dorso superne scabriusculo, cellulis laxiusculis, superioribus quadratis, c. 0·010 mm. pellucidis, minutissime papillosis, basin versus sensim longioribus, basilaribus multo majoribus, breviter rectangularibus. Caetera ignota.

Aneityum: Gunn, May-June, 1913 (Hb. Watts, 416).

Species *B. pseudo-Ehrenbergii* Fleisch. habitu similis, sed foliis angustioribus jam dignoscenda.

ORTHOTRICHACEÆ.

Macromitrium Brid.

M. orthostichum Nees.

Futuna: Gunn, Oct., 1912 (Hb. Watts, 328).

M. Reinwardtii Schwgr.

Aneityum; Gunn, March, 1911 (Hb. Watts, 237). Previous range: Sunda Islands, Tahiti, Tasmania.

M. subtile Schwgr.

Santo: Bowie, 1909 (Hb. Watts, 29, 65, 91); Futuna: Gunn, 1910 and 1912 (Hb. Watts, 207, 287, 317). Previous range: Tahiti and Eimio.

BRYACEÆ.

Brachymenium Schwgr.

B. indicum (D. et M.) Br. Jav.

Aneityum: Gunn, 1912 and 1913 (Hb. Watts 270, 439). Previous range: Java and Amboina.

RHIZOGONIACEÆ.

Rhizogonium Brid.

R. medium Besch.

Aneityum: Gunn, Feb. 1913 (Hb. Watts, 351).

R. setosum (Mitt.) Mitt.

Futuna: Gunn, 1910 (Hb. Watts, 205); Aneityum: id., 1911 (Hb. Watts, 189, 233, 220, 275, etc.), 1913, north side of island (Hb. Watts, 403); Epi: Riddle, 1911, above 2,000 feet (Hb. Watts, 141). Previous range: Samoa, Tahiti, Aneityum.

R. spiniforme (L.) Bruch.

Tangoa, Santo: Bowie, 1906 (Hb. Watts, 60, comm. Murdoch); 1909 (Hb. Watts, 44, 45, 46, 48, 71); Aneityum: Gunn, 1911 (Hb. Watts, 232, 238), July-Aug., 1913 (481); Futuna, Oct., 1912 (309).

BARTRAMIACEÆ.

Philonotis Brid.

P. laxissima (C.M.) Br. jav.

Aneityum, south-west side: Gunn, May-June, 1913 (Hb. Watts, 426).

P. obtusifolia Mitt.

Tangoa, Santo: Bowie, 1906 (Hb. Watts, 67, comm. Murdoch). Previous record: Fiji.

POLYTRICHACEÆ.

Pogonatum P. Beauv.

P. circinatum Besch.

Aneityum, south-west side: Gunn, May-June, 1913 (Hb. Watts, 437). Previous record: New Caledonia.

Group PLEUROCARPI.

CYRPTOPODACEÆ.

Bescherellea Dub.

B. elegantissima Besch.

Aneityum: Gunn, March, 1911 (Hb. Watts, 246), Aug., 1912 (273), south-west side, 1913 (415). Evidently wide-spread on the island. Previous record: New Caledonia.

SPIRIDENTACEÆ.

Spiridens Nees.

S. flagellosus Schimp.

Santo: Bowie, 1909-10; Epi: Riddle, Feb., 1911; Futuna and Aneityum: Gunn, 1911-13 (Plentiful, but all the specimens sterile). Previous record: Fiji.

S. Reinwardtii Nees.

Santo: Bowie, 1909 (Hb. Watts, 35, 180); Aneityum: Gunn, 1911 (188 c.fr.). Previous range: Java, Celebes, Timor, Philippines, Papua.

MYURIACEÆ.

Myurium Schimp. (*Œdicladium* Mitt.)

M. purpuratum (Mitt.) Broth.

Aneityum: Gunn, 1911-13 (Hb. Watts, 146, 218, 346, 476, etc.) Previous record: Aneityum.

NECKERACEÆ.

Pterobryella (C. M.) C. M.

P. vagapensis C. M.

Aneityum: Gunn, July-Aug., 1913 (Hb. Watts, 467). Previous record: New Caledonia.

Endotrichella C. M.

E. Campbelliana Hpe.

Locality and collector doubtful (Hb. Watts, 265); Aneityum: Gunn, 1913 (501).

Euptychium Schimp.

E. Gunnii Broth et Watts, n.sp.

Dioicum; robustiusculum, luescens, nitidum; *caules* secundarii usque ad 11 cm. longi, flexuosi, superne saepe curvati, dense foliosi, simplices vel parce ramosi; *folia* patula, plicata, concaviuscula, ovato-oblonga, in acumen breviter subulatum attenuata, marginibus erectis, apice minutissime serrulatis, cellulis elongatis, angustis,

incrassatis, lumine angustissimo, flexuosulo, basilaribus brevioribus et laxioribus, omnibus levissimis; *bracteae perichaetii* internae alte convolutae, subsensim in acumen longissimum, loriformi-subulatum, minutissime serrulatum attenuatae; *seta* brevissima; *theca* erecta, breviter oblonga, fusca; *peristomium* normale. Caetera nota.

Aneityum: Gunn, 1911 (Hb. Watts, 145, 225, c. fr.; Hb. Lillie, 536); Feb. 1913 (Hb. Watts, 358, 366), May-June, 1913 (422, 424, 435, 462).

Species foliis patulis, dorso levibus dignoscenda.

E. assimile Broth. et Watts, n.sp.

Species præcedenti habitu persimilis, sed statura minore folisque apice argutius serratis, cellulis superioribus brevioribus, lumine latiore dignoscenda.

Futuna: Gunn, 1910 (Hb. Watts, 208, Hb. Lillie, 530); Aneityum: Gunn, 1611 (Hb. Watts, 181).

Symphysodon Doz. et Mk.

S. Gunnii Broth. et Watts, n.sp.

Dioicus; gracilis, lutescenti-viridis, nitidus; *caules* secundarii remotiusculi, usque ad 22 cm. longi, inferne simplices, foliis squamæformibus remotis, plerumque destructis, dein dense foliosi, laxe pinnatim ramosi, ramis erecto-patentibus, usque ad 5 cm. longis, superne decrescentibus, dense foliosis, singulis longioribus, parce ramulosis; *folia* patentia, concava, e basi subcordata oblonga, subito loriformi-subulata, marginibus superne subconniventibus, integris, subula tantum minutissime serrulatis, nervis binis, brevissimis vel nullis, cellulis linearibus, flexuosulis, haud incrassatis, inter se porosis, alaribus paucis, parenchymaticis, minutis, fuscis; *brachteae perichaetii* internae alte convolutaceae, in subulam elongatam, loriformem, integram sensim attenuatæ; *seta* brevissima, lutea; *theca* erecta, immersa, oblonga, pachydermis, demum fusca; *exostomii* dentes geminati, lutei, leves; *spori* ovales, c. 0·35 mm. longi; *operculum* e basi conica breviter rostratum; *calyptra* minuta mitraeformis, operculo brevior nuda.

Futuna: Gunn, 1910 (Hb. Watts, 202), Oct. 1912 (296, forma viridis); Aneityum, 1911, Gunn (221); Epi: Riddle, Jan., 1911 (Hb. Watts, 131, c. fr., and 142).

Species pulcherrima, *S. vitiano* affinis, sed statura graciliore, caule elongato oculo nudo jam dignoscenda.

S. Micholitzii Broth.

Santo: Bowie, 1909 (Hb. Watts, 87 ex p., mixed with *S. vitianus*). Previous range: New Ireland and Papua.

S. vitianus (Sull.) Broth.

Tangoa, Santo: Annand, 1903 (Hb. Watts, 18), Bowie, 1906 (comm. Murdoch), 1909 (Hb. Watts, 51, 51a); Aneityum: Gunn, 1911 (184, 226-*S. assimile* olim), 1913 (406, 468); Epi: Riddle, Aug., 1911 (Hb. Watts, 155). Previous range: Fiji and Samoa.

Symphysodontella Fleisch.

S. cylindracea (Mont.) Fl.

Aneityum: Gunn, Feb., 1913 (Hb. Watts, 369). Previous range: Sumatra, Java, Tahiti, Samoa, Rarotonga, Cooks Island.

Papillaria (C. M.) C. M.

P. helictophylla (Mont.) Broth.

Futuna: Gunn, Oct., 1912 (Hb. Watts, 331). Previous range: Tahiti and the Marquesas Islands.

P. (Eupapillaria) pellucida Broth. et Watts. n.sp.

Dioica; gracillima, viridis, aetate ferruginea, opaca; *caulis* pendulus, usque ad 20 cm. longus, dense foliosus, laxe pinnatim ramosus, ramis patentissimis, usque ad 1 cm. longis, singulis longioribus, attenuatis; *folia* sicca imbricata, humida erecto-patentia, concaviuscula, haud plicata, e basi breviter decurrente auriculata, ovato-lanceolata, anguste acuminata, marginibus integerrimis, ad alas, saepe inflexas crenulatis, nervo infra apicem folii evanido, cellulis laminalibus ellipticis, lumine angusto, papillosis obscuris, marginalibus ultra medium folii pellucidis, levibus, basilaribus lumine longiore, pellucidis, levissimis. Caetera ignota.

Futuna: Gunn, Dec., 1910 (Hb. Watts, 212, 236, 239); 1911 (295); Aneityum: Gunn, March, 1911 (240).

Species *P. filipendulae* (Hook. f. W.) Jaeg. habitu simillima, sed cellulis marginalibus ultra medium folii pellucidis, levibus dignoscenda.

Meteorium D. et M.

M. miquelianum (C. M.) Fleisch.

Epi: Riddle, Jan., 1911 (Hb. Watts, 125); Futuna: Gunn, 1912 (293, 294, 306); Aneityum: Gunn, 1913 (376, 465). Var. Futuna: Gunn, Oct., 1910 (Hb. Watts, 211). Previous range: Papua, East Indian Archipelago, Japan, Ceylon, etc.

Aërobryopsis Fleisch.

A. longissima (D. et M.) Fl.

Tangoa, Santo: Bowie, 1906 (Hb. Watts, 113, comm. Murdoch) 1909 (115); Epi: Riddle, 1911 (137 e. p.); Aneityum: Gunn, 1913 (Hb. Watts, 361, 436b, 463). Previous range: Ceylon, Malacca, Indian Archipelago to Papua, Samoa and Sandwich Islands.

A. striatula (Mitt) Broth.

Epi, 2,000 feet: Riddle, Jan., 1911 (Hb. Watts, 136); Aneityum and Futuna: Gunn, 1911-13 (Hb. Watts, 186, 251, 321, 323-4, 419, 436). Range: South Sea Islands.

A. vitiana (Sull.) Fleisch.

Tangoa, Santo: Bowie. 1906 (Hab. Watts, 119, comm. Murdoch) Previous range: New Caledonia, Fiji, Tahiti.

Floribundaria C. M.

F. floribunda (D. et M.) Fleisch.

Tangoa, Santo: Annand, 1903 (Hb. Watts, 25). Range widespread, including Polynesia, Papua, Japan, Ceylon, the Himalayas, Madagascar, South Africa.

F. pseudo-floribunda Fl.

Santo: Bowie, 1909; Futuna and Aneityum: Gunn, 1910-13 (Hb. Watts, 286, 290, 299, 363, 464, etc.); Paama: Gunn and

Frater, 1912; Epi: Riddle, 1911. Previous range: Papua and Java. Var. *tenuiramea* var. nov. Futuna: Gunn, 1911 (Hb. Lillie).

Orthorrhynchium Reichdt.

O. cylindraceum (Lindb.) Broth.

Tangoa, Santo: Annand, 1903 (Hb. Watts, 16a) Previous range: Tahiti, Fiji, Samoa-Marquesas-Sandwich Islands.

Calyptothecium Mitt.

C. Urvilleanum (C. M.) Broth. (including *C. prælongum* Mitt.)

Santo: Bowie, 1909 (Hb. Watts, 31). Range: Carolines, New Caledonia, Tahiti, Fiji, Samoa.

Neckeropsis Reichdt., emend. Fleisch.

N. Lepineana (Mont.) Fl.

Futuna and Aneityum: Gunn, 1910-13 (Hb. Watts, 210, 364, 411, 420); Epi 2,000 feet: Riddle, Jan., 1911 (Hb. Watts, 128); Paama: Gunn and Frater, 1912 (252, c. fr.). Range widespread among the East Indies and the Pacific Islands.

Himantocladium (Mitt.) Fleisch.

H. loriforme (Br. jav.) Fl.

Epi, above 1,000 feet: Riddle, Aug. 1911 (Hb. Watts, 165). Range: Celebes, Ceram, Java, Borneo, Fiji, Samoa.

Homaliodendron Fleisch.

H. dendroides (Hook.) Fl.

Futuna and Aneityum: Gunn, 1910-13 (Hb. Watts, 149, 182, 204, 223, 305, 308, 479). Range: Pacific Islands, including Fiji, New Caledonia, Hawaii.

Thamnium Br. Eur.

T. aneitense Mitt.

Aneityum: teste Broth., *Bryales*, p. 863.

LEMBOPHYLLACEÆ.

Camptochaete Reichdt.

C. Leichhardtii (Hpe.) Broth.

Aneityum: Gunn, 1911 (Hb. Watts, 483; Hb. Lillie, 703). Range: East Australia and New Hebrides.

C. (*Eucamptochaete*) *prolongata* Broth et Watts, n.sp.

Dioica; gracilis, cæspitosa, cæspitibus laxis, rigidis, pallide lutescenti-viridibus, nitidis; *caulis primarius* elongatus; *caules secundarii* remoti, usque ad 8 cm. longi, breviter stipitati, arbusculose ramosi, ramis elongatis, laxiuscule et complanate foliosis, plerumque in flagellam elongatam attenuatis, laxe et irregulariter ramulosis, ramulis patentibus, vix ultra 1 cm. longis, singulis longioribus, plerumque attenuatis; *folia ramea* erecto-patentia, cochleariformi-concava, breviter ovato-oblonga, breviter acuminata, acuta, marginibus erectis, superne incurvis ibidemque minutissime serrulatis, nervis binis, brevibus, cellulis linearibus, incrassatis, lumine angustissimo, flexuosulo, apice papillose exstante, alaribus paucis, minutis. Caetera ignota.

Aneityum: Gunn, 1912 (Hb. Lillie, 749).

Species *C. porotrichoidi* (Besch.) valde affinis, sed ramis elongatis, laxiuscule foliosis, plerumque in flagellam elongatam attenuatis ut videtur diversa.

C. porotrichoides (Besch.) Broth.

Aneityum (north side): Gunn, May-June, 1913 (Hb. Watts, 405).

ENTODONTACEÆ.

Clastobryum D. et M.

C(?). *hebridense* Broth. n.sp.

Dioicum, tenellum, caespitosum, caespitibus densis, pallide viridibus, hic illic rufescentibus, nitidiusculis; *caulis* repens, densissime ramosus, ramis vix ultra 5 mm. longis, suberectis, dense foliosis, apice saepe propagulis numerosis, filiformibus, articulatis,

fuscis instructis; *folia ramea* sicca suberecta, humida patentia, concava, oblongo-lanceolata, subulato-acuminata, acumine plerumque semitorto, marginibus erectis, inferne minute, superne argute serratis, enervia, cellulis anguste linearibus, apice papilla alta instructis, alaribus c. 4, magnis, oblongo-vesciculæformibus, fuscis. Caetera ignota.

Aneityum: Gunn, Feb., 1913 (Hb. Watts, 387).

Species curiosissima, foliorum structura a congeneribus omnibus diversissima, forsan typus novi generis.

Entodon C. M.

E. pallidus Mitt.

Epi, 2,000 feet: Riddle, Jan. 1911 (Hb. Watts, 126, 130); Futuna: Gunn, Oct. 1912 (304). Range: East Australia, New Ireland, New Hebrides, Lord Howe Island, Tahiti.

HOOKERIACEÆ.

Distichophyllum D. et M.

D. Mittenii Br. jav.

Aneityum, south-west side: Gunn, May-June, 1913 (Hb. Watts 429). Range: Ceylon, Java, New Caledonia.

D. vitianum (Sull.) Besch.

Futuna: Gunn, Oct., 1912 (Hb. Watts, 334). Range: New Caledonia, Fiji, Samoa.

Callicostella (C. M.) Jaeg.

C. Campbelliana (Hpe) Jaeg.

New Hebrides: teste Broth., Bryales, p. 938.

C. Fraterі Broth. et Watts, n.sp.

Autoica; tenella, cæspitosa, cæspitibus densis, mollibus, depressis, laete viridibus, opacis; *caulis* repens, per totam longitudinem fusco-radiculosus, dense et complanate foliosus, subpinnatim ramosus, ramis patentibus, vix ultra 5 mm. longis, singulis longioribus, cum foliis usque ad 2 mm. latis, simplicibus, obtusis; *folia* sicca contracta, subcrispula, humida planiuscula, lateralia

patentia, late ovato-ligulata, breviter et late acuminata, apiculo acuto terminata, marginibus apice minute serrulatis, nervis binis, tenuibus, infra apicem folii evanidis, superne dorso serratis, cellulis haud incrassatis, laxiusculis, pellucidis, ovali-hexagonis, papilla media alta instructis, basilaribus longioribus et laxioribus; *seta* vix ultra 5 mm. alta, tenuissima, rubra, superne scaberrima, inferne levis; *theca* horizontalis, minuta, atrofusca; *operculum* sporangio brevius; *calyptra* apice scaberrima.

Paama: Gunn et Frater, 1912 (Hb. Watts, 259).

Species *C. papillatae* (Mont.) Mitt. affinis, sed seta superne scaberrima jam dignoscenda.

C. oblongifolia (Sull.) Jaeg.

Tangoa, Santo: Annand, 1903 (Hb. Watts, 2). Previous range: Samoa, Fiji.

Chaetomitrium D. et M.

C. aneitense Broth. et Watts, n.sp.

Dioicum; gracile, cæspitosum, cæspitibus densis, laete viridibus sericeo-nitidis; *caulis* elongatus, repens, dense ramosus, ramis usque ad 2 cm. longis, dense foliosis, dense ramulosis, ramulis adscendentibus, brevibus; *folia ramea* sursum vergentia, lanceolata, acuta, marginibus recurvis, inferne minute, superne argute serratis, nervis binis, brevissimis, cellulis anguste linearibus, apice papillose exstante. Caetera ignota.

Aneityum: Gunn, 1913 (Hb. Watts, 474).

Species *Ch. nematoso* Broth. affinis, sed filis caulinis deficientibus necnon foliis dorso minutius papillosis dignoscenda.

C. Geheebii Broth.

Tangoa, Santo: Bowie, 1906 (Hb. Watts, 110b, and 177, comm. Murdoch). Previous range: Queensland and Papua.

HYPOPTERYGIACEÆ.

Cyathophorella (Broth.) Fleisch.

C. spinosa (C. M.) Fleisch.

Santo: Bowie, 1909 (Hb. Watts, 68).

C. tahitensis (Besch.)
Aneityum: Gunn, 1913 (Hb. Watts, 337).

Hypopterygium Brid.

H. (*Tamariscina*) *Bowiei* Broth. et Watts, n.sp.

Dioicum; robustiusculum, pallide viride, opacum; *caulis primarius* repens, fusco-tomentosus; *caules secundarii* e stipite nudo usque ad 2 cm. longo, foliis squamaeformibus remotis, squarroso-patulis instructo in frondem semicircularem producti, ramis dense pinnatim ramulosis; *folia* ovato-ovalia, apiculata, limbata, limbo hyalino, biseriato, superne serrato, nervo paullum ultra medium folii evanido, cellulis ovali-hexagonis; *amphigastria* ovata vel ovalia, raptim in cuspidem robustum attenuata, anguste limbata, minutissime serrulata, nervo tenuissimo, medio folii evanido vel obsoleto; *perigonia* numerosa secus ramos. Planta feminea ignota.

Santo: Bowie (Hb. Watts, 73, comm. Murdoch).

Species *H. tahitensi* Aongstr. affinis, sed ramis pinnatim ramulosis dignoscenda.

H. (*Lopidium*) *javense* (Hamp.) Jaeg.
Aneityum: Gunn, Feb., 1913 (Hb. Watts, 381).

H. Micholitzii Par.
Santo: Bowie, 1908 (Hb. Watts, 72). Previous range: Luzon and Papua.

H. (*Tamariscina*) *neo-caledonicum* Besch.
Futuna: Gunn, Oct., 1912 (Hb. Watts, 330); Aneityum: id., 1913 (427 south-west side, 455, 480).

RHACOPILACEÆ.

Rhacopilum Palis.

R. cuspidiferum (Schwgr.) Mitt.
Tangoa, Santo: Annand, Aug., 1903 (Hb. Watts, 7, 12, 22). Range: Sandwich Islands and Norfolk Island.

R. pacificum Besch.
Futuna: Gunn, Oct., 1912 (Hb. Watts, 314, 332).

R. spectabile Reinw. et Hsch.

Santo: Bowie, 1909 (Hb. Watts, 121); Futuna: Gunn, Oct., 1912 (312, 316 e. p.); Aneityum, north side, May-June, 1913 (409). Previous range: Java, Sumatra, Mindanao, Papua, New Caledonia, Fiji, Samoa.

LESKEACEÆ.

Herpetineuron (C. M.) Card.

H. toccoæ (Sull. et Lesq., as *Anomodon*) Card.

Epi, above 1,000 feet: Riddle, Aug., 1911 (Hb. Watts, 162); 2,000 feet, Jan. 1911 (264). A very widespread species, but not previously recorded for the New Hebrides.

Pelekium Mitt.

P. velatum Mitt.

Tangoa, Santo: Annand, 1903 (Hb. Watts, 1 e. p., 5, 14 c.fr.); Epi, 2,000 feet: Riddle, Jan. 1911 (124). Previous range: Java, Sumatra, Borneo, Philippines, Papua, Bismarck Archipelago, Solomons, Admiralties, Samoan Islands.

Thuidium Br. Eur.

T. Campbelliana (Hpe.) Jaeg.

New Hebrides: teste Broth., Bryales, p. 1017 ("eine mir unbekannte Art": Broth.).

T. cymbifolium (D. et M.) Br. jav.

Santo: Bowie, 1909 (Hb. Watts, 35 and 36); Aneityum: Gunn, 1913 (386 e. p.). Previous range: India, Sumatra, Java, Celebes, Tonkin, China, Japan, found also recently on Lord Howe Island.

T. glaucinoides Broth.

Tangoa, Santo: Bowie, 1906 (Hb. Watts, 178, comm. Murdoch), 1909 (81-86). Previous range: Birma, Karen Hills, Natunas, Sunda Islands, Tonkin, Formosa, etc.

T. glacinum (Mitt.) Broth.

Santo: Bowie, 1909 (Hb. Watts, 34, 38); Epi: Riddle, Aug., 1911, 1,000 – 2,000 feet (129, 153); Aneityum: Gunn, Feb., 1913 386 e. p.). Previous range; India, Ceylon, Assam, Japan.

T. plumulosum (D. et M.) Br. jav.

Tangoa, Santo: Annand, Nov., 1903 (Hb. Watts, 3, 19). Previous range: Ceylon, Sunda Islands, Philippines, Papua, New Hanover, Admiralties, Fiji.

T. ramentosum Mitt.

Epi: Riddle, 1911 (Hb. Watts, 268), 2,000 feet (129, 157); Aneityum: Gunn, Aug., 1912 (274), May-June, 1913, north side (400, 408), south-west side (430). Previous range: East Australia, Norfolk Island, Fiji, Samoa.

HYPNACEÆ.

Stereodonteæ.

Ectropothecium Mitt.

E. aneitense Broth. et Watts, n.sp.

Dioicum; robustiusculum, cæspitosum, cæspitibus densis, molliculis, lutescenti-viridibus, nitidis; *caulis* elongatus, repens, dense foliosus, dense et regulariter pinnatim ramosus, ramis patulis, brevibus, vix ultra 5 mm. longis; *folia caulina* concaviuscula, falcata, ovato-lanceolata, filiformiter acuminata, marginibus erectis, superne serratis, nervis binis, brevissimis vel indistinctis, cellulis anguste linearibus, levibus, basi alaribus infimis abbreviatis, alaribus paucis, magnis, hyalinis; *folia ramea* argutius serrata. Caetera ignota.

Aneityum: Gunn, 1912 (Hb. Lillie, 760, 761), Feb., 1913 (Hb. Watts, 379, 382b).

Species mollitie foliisque, præsertim rameis superne argute serratis dignoscenda.

E. Bowiei Broth. et Watts, n.sp.

Dioicum; gracilescens, rigidum, viride, aetate fuscescenti-viride, nitidum; *caulis* elongatus, repens, dense foliosus, dense et regulariter pinnatim ramosus, ramis patentibus, usque ad 1 cm. longis; *folia* concaviuscula, falcata, ovato-lanceolata, breviter subulato-acuminata, marginibus erectis, minute serrulatis, nervis binis, brevissimis vel indistinctis, cellulis breviter linearibus, scaberulis,

basilaribus infimis laxis, hyalinis; *bracteae perichaetii* e basi vaginante raptim breviter subulatae, acumine reflexo, serrulato; *seta* c. 2·5 cm. tenuis, fuscescenti-rubra; *theca* minuta, nutans, ovalis, fusca; *operculum* e basi convexa breviter rostratum.

Santo: Bowie, 1909 (Hb. Watts, 53, 106).

Species *E. intorquato* (Dz. et M.) affinis, sed statura graciliore, foliis scaberulis, setaque multo breviore jam dignoscenda.

E. Gunnii Broth. et Watts, n.sp.

Species præcedenti simillima, sed foliis subintegris, cellulis multo angustioribus, levibus dignoscenda.

Aneityum: Gunn (Hb. Watts, 383, 393, 404, 459).

E. brachyphyllum Broth. et Watts, n.sp.

Dioicum; gracilescens, cæspitosum, cæspitibus densis, depressis, viridibus, nitidis; *caulis* elongatus, repens, complanatus, densiuscule foliosus, laxe pinnatim ramosus, ramis patentibus, vix ultra 1 cm. longis; *folia* disticha, falcatula, concaviuscula, ovalia vel ovata, breviter et late acuminata, marginibus erectis, superne serrulatis, nervis binis, brevissimis vel obsoletis, cellulis breviter linearibus, sublevibus, basilaribus infimis abbreviatis, alaribus conformibus. Caetera ignota.

Aneityum : Gunn, May-June, 1913 (Hb. Watts, 425, 458).

Species *E. percomplanato* Broth. affinis, sed foliis breviter et late acuminatis, cellulis sublevibus dignoscenda.

E. Micholitzii Broth.

Epi, above 1,000 feet: Riddle, Aug, 1911 (Hb. Watts, 266); Futuna, Oct., 1912: Gunn (298). Previous record: Papua.

E. pacificum Mitt.

Aneityum: Gunn, 1911 (Hb. Watts, 150, 175), 1913 (441). Previous record: Samoan Islands.

E. percomplanatum Broth.

Santo: Bowie, 1909 (Hb. Watts, 100, 109), *Vars.* 52, 103-4, 108; Epi, 2,000 feet: Riddle, Jan., 1911 (132). Previous record: Papua.

E. sodale (Sull.) Mitt.

Santo: Bowie, 1909 (Hb. Watts, 101, 110, 122). Range: Pacific Islands generally.

Trismegistia (C. M.) Broth.

T. complanatula (C. M.) C. M.

Santo: Bowie, 1909 (Hb. Watts, 32); Aneityum: Gunn, 1912-3 (Hb. Watts, 173, 281, 283, 284, 394). Previous range: Fiji, Samoa, Papua.

T. pedunculata (Mitt.) Broth.

Aneityum: Gunn, Mch., 1911 – 1913 (Hb. Watts, 219, 222, 362). Previous record: Aneityum.

Plagiotheciecæ.

Isopterygium Mitt.

I. Gunnii Broth et Watts, n.sp.

Autoicum; gracile, cæspitosum, cæspitibus densis, mollibus, lutescentibus, nitidis; *caulis* elongatus, repens, fusco-radiculosus, dense ramosus, ramis erectis, vix ultra 5 mm. longis, dense et complanate foliosis, simplicibus, obtusis; *folia ramea* patentia, concaviuscula, ovato-lanceolata, in acumen filiforme attenuata, marginibus erectis, integris vel superne minutissime serrulatis, enervia, cellulis anguste linearibus, basilaribus infimis laxis, abbreviatis, hyalinis; *bracteae perichaetii* internae e basi lata, superne argute inciso-serrata in acumen patulum longe et anguste subulatum, serrulatum raptim attenuatae; *seta* c. 1·5 cm. alta, tenuissima, rubra; *theca* horizontalis, minuta, asymmetrica, obovata, fusca; *operculum* e basi conica obtuse apiculatum.

Futuna: Gunn, Dec., 1910 (Hb. Watts, 209, Hb. Lillie, 519).

Species pulchella, mollitie, foliis filiformiter attenuatis bracteisque internis superne argute inciso-serratis dignoscenda.

I. taxirameum (Mitt.) Jaeg.

Santo: Bowie, 1909 (Hb. Watts, 118); Epi, 2,000 feet: Riddle, 1911 (133, 263); Futuna: Gunn, 1912 (316, 335, 310, 291, 322). Previous range: Himalaya, Khasia, Ceylon, Sumatra, Formosa, Assam, Japan.

Taxithelium Spruce.

T. (*Polystigma*, *Aptera*) *Annandii* Broth. et Watts, n.sp.

Autoicum; gracile, cæspitosum, cæspitibus densis, depressis, laete viridibus opacis; *caulis* repens, per totam longitudinem hic illic fusco-radiculosus, dense et complanate foliosus, subpinnatim ramosus, ramis patentibus, brevibus, valde complanatis, obtusis; *folia* disticha, concava, lateralia erecto-patentia, ovato-vel elliptico-lanceolata, breviter subulato-acuminata, marginibus erectis, sub-integris, cellulis elongatis, augustis, seriatim papillosis, basilaribus infimis laxis, hyalinis, levissimis; *bracteae perichaetii* internae e basi vaginante raptim longissime subulatae, acumine recurvo, minute serrulato; *seta* vix ultra 5 mm. alta, tenuissima, rubra, levissima; *theca* suberecta vel subnutans, minutissima, ovalis, sicca deoperculata sub ore paulum constricta, fusca; operculum breviter rostratum.

Tangoa, Santo: Annand, Dec., 1903 (Hb. Watts, 10, 17, 21 e.p.)

Species *T. nitidulo* Broth. et Par. valde affinis, sed theca minutissima, ovali jam dignoscenda.

T. papillatum (Harv.) Broth.

Aneityum: Gunn, 1913 (Hb. Watts, 471, 473, 477, 484, 486, 490-3, 498). Previous range: Nepal, Malacca and Siam, the Sunda Islands, Papua, Fiji and Samoan Islands.

T. substigmosum (C. M.) Broth.

Tangoa, Santo: Bowie, 1906 (Hb. Watts, 59, comm. Murdoch). Previous record: Papua.

Vesicularia (C. M.) C. M.

V. inflectens (Brid.) C. M.

Epi, 2,000 feet: Riddle, Aug., 1911 (Hb. Watts, 127, 166, 169 c. fr.) Range: Hongkong and the Pacific Islands.

Plagiotheciopsis Broth.

P. oblonga (Broth.) Broth.; *Ectropothecium oblongum* Broth. in Oefvers. Finska Vet. Soc. Forh. XXXVII, p. 170 (1895); *Vesicularia oblonga* Broth. in Engl.-Prantl., p. 1095 (1908).

New Hebrides: Micholitz.

SEMATOPHYLLACEÆ.

Trichosteleum (Mitt.) Jaeg.

T. hamatum (Doz. et M.) Jaeg., var. *semimammillosum* (C. M.) Par.

Aneityum: Gunn, Feb., 1913 (Hb. Watts, 382a). Previous range: Papua.

T. (*Thelidium*) *subtile* Broth. et Watts, n.sp.

Autoicum; tenellum, cæspitosum, cæspitibus densis, viridissimis, opacis; *caulis* repens, fusco-radiculosus, dense foliosus, vage ramosus, ramis erectis, brevibus, complanatulis; *folia* falcatula, concava, oblongo-lanceolata, breviter subulato-acuminata, marginibus erectis, apice minute serrulatis, enervia, cellulis breviter ellipticis, papillis pluribus, dorso valde prominentibus instructis, basin versus sensim longioribus, alaribus c. 4, magnis, oblongis, vesiculosis, hyalinis; *bracteae perichaetii* internae erectae, e basi vaginante raptim subulatae, superne argute serratae; *seta* c. 5 mm. alta, tenuissima, rubra, apice grosse papilloso; *theca* nutans, minuta, ovalis, sicca deoperculata sub ore valde constricta, grosse mammillosa, fusca; *operculum* e basi conica oblique subulatum.

Paama: Gunn and Frater, June, 1912 (Hb. Watts, 256, 258).

Species *T. hamato* var. *semimammilloso* (C. M.) affinis, sed foliis multo brevioribus, cellulis elevato-papillosis dignoscenda.

T. (*Thelidium*) *Pickeringii* (Sull.) Jaeg.

Tangoa, Santo: Annand, Dec., 1903 (Hb. Watt, 11, 21 e. p.); Aneityum: Gunn, 1913 (382 e. p., 485, 488, 489a, 496-7, 500 e. p.) Range: Pacific Islands.

T. (*Papillidium*) *Gunnii* Broth. et Watts, n.sp.

Autoicum; gracile, cæspitosum, cæspitibus densiusculis, lutescentibus, opacis; *caulis* repens, per totam longitudinem fusco-radiculosus, dense foliosus, subpinnatim ramosus, ramis erecto-patentibus, brevibus, complanatis; *folia* sicca suberecta, humida erecto-patentia, concava, oblongo-elliptica, breviter lanceolata vel lanceolato-subulata, marginibus erectis, inferne minutissime, apice

distinctius denticulatis, enervia, cellulis anguste ellipticis, papilla media, elevata instructis, infimis aureis, alaribus c. 4, magnis, oblongis, vesiculosis, aureis vel fusco-aureis; *bracteae perichaetii* internae erectae, e basi vaginante raptim longe subulatae, superne serratae; *seta* c. 9 mm. alta, tenuissima, rubra, apice grosse papillosa; *theca* pendula, minutissima, ovalis, grosse mammillosa, sicca deoperculata sub ore constricta, fusca. Caetera ignota.

Aneityum: Gunn, 1912 (Hb. Lillie, 755), Feb., 1913 (Hb. Watts, 384, 382c).

Species *L. LeRatii* Broth. et Par. valde affinis, sed statura paulum robustiore foliisque brevius acuminatis dignoscenda.

Sematophyllum (Mitt.) Jaeg.

S. bunodiocarpum (C. M.) Broth.

Aneityum: Gunn (or Epi: Riddle) 1911 (Hb. Watts 172, 176); Aneityum: Gunn, Aug., 1912 (277). Previous record: Papua.

S. glabrifolium Broth. et Watts, n.sp.

Gracillimum, cæspitosum, cæspitibus densis, mollibus, pallide viridibus, sericeis; *caulis* repens, fusco-radiculosus, hic illic filis elongatis, articulatis, fuscis instructus, densissime ramosus, ramis erectis, vix ultra 5 mm. longis, dense foliosis, simplicibus; *folia ramea* erecto-patentia, concava, anguste lanceolata, breviter subulato-acuminata, marginibus anguste revolutis, inferne minute, superne distinctius serrulatis, enervia, cellulis haud incrassatis, angustissimis, levissimis, alaribus minutis, oblongis, vesiculosis, fuscis. Caetera ignota.

Aneityum, south-west side: Gunn, May-June, 1913 (Hb. Watts, 436a).

Species distinctissima, *S. Etessei* Broth. et Par. affinis, sed foliis brevius acuminatis, minutius serrulatis, cellulis levissimis optime diversa.

S. serricalyx Broth. et Watts, n.sp.

Pseudautoicum; robustiusculum, cæspitosum, cæspitibus densis, lutescenti-viridibus, nitidis; *caulis* repens, dense ramosus, ramis

elongatis, adscendentibus, dense foliosis, pinnatim ramulosis, ramulis erecto-patentibus, vix ultra 1 cm. longis; *folia* patula, concava, e basi subcordata ovalia, breviter acuminata, marginibus erectis, superne incurvis, apice subconniventibus, integris vel subintegris, enervia, cellulis incrassatis lumine angustissimo, infimis abbreviatis, aureis, alaribus magnis, vesiculosis, oblongis, aureis, externis hyalinis, omnibus levissimis; *bracteae perichaetii* internae erectae, e basi vaginante subsensim in acumen subulatum, serratum attenuatae; *seta* 1·5-2 cm. alta, tenuis, rubra, apice scaberula; *theca* inclinata vel subhorizontalis, minuta, ovalis, sicca deoperculata sub ore vix contracta, fusca; *operculum* e basi conica subulatum. *Planta mascula* minutissima, foliis affixa.

Santo: Bowie, 1909 (Hb. Watts, 56 e. p., 63 c. fr.); Epi: Riddle, Jan., 1911 (135); Aneityum: Gunn, Aug., 1912 (282), May-June, 1913 (398 e. p., 444, 447, 457); Futuna: Gunn, Oct., 192 (329).

Species *S. brevicuspidata* (Mitt.) habitu similis, sed inflorescentia bracteisque perichaetii serratis dignoscenda.

S. sigmatodontum (C. M.) Jaeg.

Santo: Bowie, 1909 (Hb. Watts, 50, 56 e. p.). Previous range: Sumatra, Java, Papua.

S. turgidum (Doz. et M.) Jaeg.

Aneityum: Gunn, Feb., 1913, *var.* (Hb. Watts, 360); North side, May-June, 1913 (Hb. Watts, 399). Previous range: Ceylon and Sunda Islands.

BRACHYTHECIACEÆ.

Rhynchostegium Br. Eur.

R. javanicum (Bel.) Besch.

Santo: Bowie, 1909 (Hb. Watts, 114). Previous range: Java and Sumatra.

R. menadense (Br. jav.) Jaeg.

Epi: Riddle, Aug. 1911, above 1,000 feet (Hb. Watts, 134 e.p., 164). Previous range: Celebes and Tonkin.

R. oblongifolium Broth. et Watts, n.sp.

Autoicum; robustiusculum, cæspitosum, cæspitibus densiusculis, extensis, laete viridibus, nitidis; *caulis* elongatus, filiformis, foliis plerumque destructis, vage ramosus, ramis plus minusve elongatis, laxiuscule et complanate foliosis, attenuatulis, subpinnatim ramulosis: *folia ramea* distiche patula, late oblonga, in apiculum raptim contracta, marginibus infima basi recurvis, dein erectis, argute serratis, nervo crassiusculo, infra apicem folii evanido, apice exstante, cellulis anguste linearibus, flexuosulis, basilaribus infimis laxiusculis, alaribus haud diversis. Caetera ignota.

Santo: Bowie, 1909 (Hb. Watts, 116). Futuna: Gunn, Oct., 1912 (302).

Species *R. javanico* affinis, sed foliorum forma optime diversa.

HYPNODENDRACEÆ.

Hypnodendron (C. M.) Lindb.

H. (*Phœnicobryum*) *flagelliferum* Broth. et Watts, n.sp.

Dioicum; robustiusculum, viride, aetate rufescens, nitidiusculum; *caulis secundarius* erectus, usque ad 7 cm. longus, stipite usque ad 3 cm. longo, nudo, laxe folioso, superne pinnatim ramosus, ramis erecto-patentibus, laxiusule et complanate foliosis, flagellis numerosis elongatis, tenuissimis, plerumque axillaribus instructis; *folia* stipitis laxe disposita, squarroso-patula, late cordato-ovata, longe et anguste lanceolato-subulata, marginibus erectis, basi minutissime, dein distinctius et geminato-serratis, nervo sat tenui, longe excedente, levi, cellulis incrassatis, elongatis, lumine angustissime lineari, levissimis; *folia caulina* erectiora, majora, argutius serrata; *folia ramea* minora, angustiora, argute serrata. Caetera ignota.

Aneityum: Gunn, 1911 (Hb. Watts, 144, Hb. Lillie, 689), 1912 (Hb. Lillie 746); May-June, 1913 (Hb. Watts, 402, north side, and 417, south-west side).

Species distinctissima, a cogeneribus ad huc cognitis longe diversa.

H. rigidum Mitt.

Aneityum: teste Broth., Bryales.

H. spininervium (Hook.) Jaeg.

Santo: Bowie, 1909 (Hb. Watts, 66); Aneityum: Gunn, 1911 (245), 1913 (374 e. p., 438); Futuna: Gunn, 1912 (300).

H. subspininervium (C. M.) Jaeg.

Aneityum: Gunn, Feb., 1913 (374 e. p., 378). Previous record: Aneityum, Fiji, Samoa.

Mniodendron Lindb.

M. Helwigii Broth.

Aneityum: Gunn, Aug., 1912 (Hb. Watts, 279, 280), Feb., 1913 (370, 372). Previous record: Papua.

M. Milnei Mitt.

Aneityum: Gunn, Oct., 1911 (Hb. Watts, 187, *M. Gunnii* in MS.; Hb. Lillie ? no., *M. Lilliei* in MS.). Previous record: Aneityum.

THE ESSENTIAL OIL OF *EUCALYPTUS SMITHII* FROM VARIOUS FORMS OF GROWTH.

By HENRY G. SMITH, F.C.S.

With Plates XIII to XXIII.

[*Read before the Royal Society of N. S. Wales, August 4, 1915.*]

THIS species was first described by my colleague, Mr. R. T. Baker, F.L.S., in the Proceedings of the Linnean Society of New South Wales, in 1899. It was more fully dealt with in our work, "A research on the Eucalypts and their essential oils," Sydney, 1902, p. 107. Since that time this species has been recorded from many localities in southern New South Wales, reaching as far north as Hill Top. As it occurs also in Victoria, the range is somewhat extensive. Under favourable conditions it grows to a large tree, but as its chief economic product is the essential oil from the leaves, its size is more a disadvantage than otherwise, particularly as the timber is of indifferent quality. It will be shown later, that the difficulty due to size may be overcome and the trees grown in a shrubby form, thus making the leaves more readily accessible for oil distillation.

The time is rapidly approaching when it will be considered advisable, and found to be profitable, to cultivate or reafforest with the best species for the required kinds of essential oils obtainable from the members of this great genus. The time seems opportune, therefore, to direct attention to the advantages which *Eucalyptus Smithii* offers for cultivation. It produces, perhaps, the best cineol-pinene Eucalyptus oil obtainable from any species.

I am indebted to my colleague Mr. R. T. Baker, the Curator of the Technological Museum, for botanical assist-

ance in the preparation of this paper, and to Mr. D. E. Chalker of Hill Top, who has distilled Eucalyptus oil from this species for the last ten years. He has given me much information respecting the growth of the species, and provided some of the material for distillation.

Rapidity of Growth and Reproduction.

The growth of *Eucalyptus Smithii*, under natural conditions of soil and climate, is considerable, and is more rapid with the so-called "suckers," or new growths which spring from the stumps of the felled mature trees, than with plants grown from seed, although with the seedlings the increase in height usually averages, for the first year or two, from six inches to a foot per month. As the leaves are alone required for oil distillation it is apparent that the method which will produce the greatest crop of leaves in the shortest time is the one to adopt; and in this respect the felling of the trees gives by far the best results. It was thought at one time that better results could be obtained if the branches were lopped from the trunks of the trees, but this idea has been shown to be fallacious. Considerable advantage is also derived when the trees are felled as the leaves are gathered from shrubby growths instead of from tall trees, and as labour in Australia is costly, this is, of course, a matter of some importance. The men, too, are greatly adverse to climbing the trees for the purpose of lopping off the branches, while the increased danger to the men by this method of working is also a matter for some consideration.

The vitality shown by this species is remarkable and the trees may be lopped repeatedly without destruction, and the branchlets removed again and again as the leaves are required for distillation, the reproduction appearing to be continuous over a long period of years.

The evidence as to the length of time trees of this species can withstand this cutting back appears to be wanting, but that it is considerable is shown from the data so far accumulated. The following instances will give some idea of the persistence of reproduction.

(*a*) There is a stump of *E. Smithii* about one mile on the south side of Hill Top Railway Station, on the old abandoned railway, right on the edge of the eastern side of the cutting. This tree was felled when the railway was constructed about forty years ago, and the new growth has repeatedly been chopped back since that time, yet, to-day, it is producing leaves and branchlets apparently as vigorously as ever. Mr. Chalker has cut the leaves from it for oil distillation several times, and from each gathering the leaves have apparently yielded the usual amount of oil for the species, while the oil itself has shown no difference in constitution from the normal.

(*b*) A sapling four inches in diameter, growing at Hill Top, was cut stump high in April 1913; in May 1914 the new growth had reached 15 feet in height, with an abundance of leaves; in May 1915 the leaves were cut for oil distillation.

The accompanying photographs will illustrate the various reproductive growths of this species:—

Plate XIII. Taken in 1911. This tree was felled in 1906; the top branches were first removed for oil distillation in 1908. In the photograph the tree shows three years' growth. Material has been collected from this tree for oil distillation four times in seven years, and to-day shows again good growth.

Plate XIV. This tree was a seedling, and as shown is five years old. It had been lopped twice during that period; the first time at one foot from the ground; the second time at twelve feet. When the photograph was taken the tree was over twenty feet high.

Plate XV. This tree, one foot nine inches in diameter, was felled in 1909. The photograph was taken in 1911. The growth is all from the stump, and shows about twenty "suckers" of various sizes, the largest being three inches in diameter.

Plate XVI. Growth of leaves on seedling stems which had been trimmed for oil distillation three months previously.

Plate XVII. Showing twelve months' growth of leaves on seedlings which had been felled stump high.

Plate XVIII. Growth of leaves on big tall trees the branches of which had been lopped off two years previously.

Plate XIX. Seedlings which have sprung up thickly when other Eucalyptus growth had been cleared away. This is a good illustration of natural Eucalyptus afforestation. *E. Smithii* appears to be rather delicate in its early stages, and in the struggle for existence is crowded out by such species as *E. piperita*, *E. eugenioides*, *E. quadrangulata*, etc.; but, if assisted to get a start, the result is as shown. Perhaps this peculiarity is the reason the trees of this species are often sparsely distributed.

Plate XX. Seedlings between two and three years old.

Plate XXI. The branches of this large tree had been lopped off. Through some reason the top of the tree died. The dense growth is an illustration of the vitality in the lower portion of the tree.

Plate XXII. Shows twelve months' growth from a lopped tree (the tall one on the right), and from felled trees (those in the foreground and on the left). The spreading tree in the background is not this species.

Plate XXIII (foliage). The form of leaf, (*A*) was alone produced until the seedling had grown nearly six feet in height. The rate of growth for about two weeks then

slackened, after which time it reverted to the original rate, but the leaves were all petiolate as in (*B*). (*C*) shows the venation of the mature petiolate leaves. This Eucalyptus leaf venation indicates that the oil consists of cineol and pinene and that phellandrene is absent.

* * * * * *

The rapidity of growth in localities away from the natural home of the species is illustrated by results obtained with a tree grown in my own garden at Marrickville, near Sydney. In January, 1912, seedlings, a few inches high, were brought from Hill Top. One of these grew very well, and by the end of the winter, in August of that year, was two feet three inches high. Measurements were then made every week until the end of December. During the month of September the height increased seven inches; during October the tree grew twelve inches; during November it grew fourteen inches, while at the end of December the height of the seedling was six feet. In January 1915 the height of the tree was twenty-two feet, while the diameter of the stem, eighteen inches from the ground, was three inches. In June of this year the top of the tree was removed and the leaves distilled for oil. The natural home of *E. Smithii* is on the Ranges, and at a considerable altitude, while Marrickville is near sea level. The yield of oil from this cultivated tree was practically equal in amount to that from naturally grown trees, (1·5 to 2 per cent.), and the quality of the oil and its constituents were also in agreement. This is shown from the tabulated results below.

The Essential Oil.

This investigation of the oil of *Eucalyptus Smithii*, distilled from material collected under different conditions of growth, was thought desirable in order that the variations in the amounts of constituents in the oil during these

various stages might be determined. From accumulated results obtained with a very large number of Eucalyptus species, collected during a quarter of a century of experimental research, it has been conclusively shown that the same species of Eucalyptus always yields a similar product, although the percentage amounts of the constituents characteristic of the species may vary under particular conditions. Not only is this true for trees grown under natural influences, but it appears to hold when they are cultivated. Numerous instances of this fact have accumulated, and the one now given is a good example of this constancy. It has long been known that the pinene in the cineol-pinene oils varies in amount under special conditions, and in the leaves of mature trees diminishes during the winter months, while the cineol at the same time increases correspondingly in amount. The yield of oil is also less at that period, the maximum content being present in the early spring and summer months. To determine what alterations may be expected in the percentage amounts of the chief constituents in a rich cineol-pinene oil has been the object of the present investigations.

Eucalyptus Smithii is a well defined species and has a somewhat extensive range. The oil obtained by steam distillation is one of the richest in cineol content of all Eucalyptus species so far examined. The yield of oil is also good, as much as from twenty to twenty-six pounds of oil being obtainable commercially from the leaves and terminal branchlets which can be packed in a four hundred gallon tank. The oil consists very largely of cineol, and the terpene is dextrorotatory pinene. In commercial samples the amount of high boiling constituents is often very small indeed, the original distillation not being carried to the end, and 96 per cent. or more of crude commercially distilled oil may come over below 190° C. With one sample of the oil distilled in January, 40 ℔s of crude oil were steam

distilled in the laboratory, and the residue distilled directly; only five ounces of the 40 lbs. did not distil below 190° C. equal to 0·78 per cent.

The constituents present in the oil, besides pinene and cineol, are a phenol, a small amount of volatile aldehydes, dextrorotatory eudesmol melting at 79° C., a solid paraffin melting at 64° C.,[1] a small quantity of esters, partly a low boiling one, probably butyl-butyrate,[2] and a small amount of sesquiterpene. Neither phellandrene, piperitone nor aromadendral have so far been detected in the oil of this species.

The ready way in which the chief volatile aldehyde polymerises or alters to a compound with a sweet-briar-like scent soon renders the oil pleasant both in odour and taste. The volatile cough-producing aldehydes which are often so objectionable in the oils of many species yielding a cineol-pinene product, seem to be largely absent in the oil of *E. Smithii*. The identity of the chief volatile aldehyde in the oil of this species has not yet been accurately determined, but it seems to differ from those usually present in the oils of the members of the "Gum" group, such as *E. globulus*, *E. goniocalyx*, etc., and also in those derived from some of the "Mallees."

The colour of the rectified oil of *E. Smithii*, when freshly distilled, is slightly yellow, as are most of the richer cineol oils which do not contain phellandrene. This yellowish tint is apparently due to quinone influence, and is traceable to the particular phenol present in the oils of this group of Eucalypts.[3] Through the influence of light the colour disappears, the oil eventually becoming colourless.

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1 H. G. Smith, this Journal, Vol. XLVII, p. 95, 1913.

2 H. G. Smith, this Journal, Vol. XLVIII, p. 474, 1914.

3 R. Robinson and H. G. Smith, this Journal, Vol. XLVIII, p. 518, 1915.

The optical activity of the eudesmol, which occurs in the oil of this species, was determined in the product from a three year old cultivated tree growing at Marrickville. Usually this stearoptene is present in very small amount, particularly in commercial samples, and the higher dextrorotation of the crude oil, over that of the rectified, indicated the presence of an active substance in the portion boiling above 190° C., and as eudesmol appeared to be the chief constituent in the residue it was isolated and purified. 0·2146 gram. in 10 cc. alcohol rotated the ray 0·85 degrees to the right, the specific rotation of this sample of eudesmol was, therefore, $[\alpha]_D = +39{\cdot}6°$.

It will be interesting to determine whether the difference in optical activity between eudesmol from the non-phellandrene oils, and that from the phellandrene bearing ones is of a constant character with all the species of the several groups. There is much work yet required to be done in order to determine the chemistry of this peculiar constituent, of not uncommon occurrence in Eucalyptus oils.

The comparative absence of constituents in the oil of this species which might be considered of an objectionable nature, suggested the desirability of adopting other methods for the rectification of the crude oil than that of redistillation or steam distillation. The following method answers admirably for this purpose. When the crude oil was shaken repeatedly for some hours with very dilute sulphuric acid, the reddish colour—due to the presence of a small amount of iron from the still acting on the phenol—was removed. The oil was well washed and dried by agitating with perfectly dry carbonate of soda. The product thus obtained was usually tinged yellow and had all the brilliancy of the oil when redistilled, besides retaining the small amount of phenol and traces of other constituents which may, perhaps, be found eventually to add therapeutic value to an oil of

this class. It seems quite unnecessary, therefore, to go to the expense of redistilling the crude oil of *Eucalyptus Smithii*, as it can so readily be prepared in a marketable condition by simpler methods.

The material which has furnished the oils for the present investigation was all collected from trees growing at Hill Top, in this State, with the exception of that from the cultivated tree at Marrickville. The leaves and terminal branchlets were, in all cases, cut as for commercial oil distillation and were distilled at the Technological Museum, with the exceptions of (*f*) and (*g*) below, which were distilled by Mr. Chalker.

The material worked upon is represented by the following stages of growth:—

(*a*) Leaves from lopped trees, seven months' growth; collected May 1913.

(*b*) Leaves from lopped trees, fifteen months' growth; collected May 1913.

(*c*) Leaves from seedlings, twelve months' growth; collected June 1914.

(*d*) Leaves from seedlings two and a half years old; collected July 1914.

(*e*) Leaves from cultivated tree at Marrickville; collected June 1915.

(*f*) Leaves from general material, partly young; collected January 1915.

(*g*) Leaves from general material collected three weeks later than (*f*).

(*h*) Leaves from old trees; collected March 1913.

The constants etc. given by the crude oils from the above material were as follow:—

	Specific gravity at 15° C.	Rotation α_D	Refractive index.	Solubility in 70% alcohol.	Saponification number.	Cineol per cent.
(*a*)	0·9098	+ 7·6°	1·4636 at 20°	Required 1·6 vols.	4·8	67·4
(*b*)	0·9157	+ 6·5°	1·4635 at 20°	1·2 ,,	5·6	74·2
(*c*)	0·9116	+ 9·2°	1·4650 at 19°	2·1 ,,	1·3	61·5
(*d*)	0·9139	+ 7·6°	1·4634 at 18°	1·4 ,,	4·1	69·0
(*e*)	0·9198	+ 4·7°	1·4672 at 16°	1·2 ,,	2·7	75·0
(*f*)	0·9156	+ 5·3°	1·4571 at 26°	1·1 ,,	3·3	80·7
(*g*)	0·9154	+ 5·1°	1·4574 at 25°	1·1 ,,	3·1	79·0
(*h*)	0·9210	+ 4·2°	1·4604 at 22°	1·1 ,,	1·3	85·2

The cineol was determined by the resorcinol method, in all cases in the redistilled portion of the freshly obtained oil boiling below 190°. The alcohol for solubilities was 70 per cent. by weight.

It will be noticed from the above that the oil from the younger seedlings contains more dextrorotatory pinene and less cineol than that from saplings two to three years old, and that the maximum cineol content is reached in the oil from leaves collected from older trees. This is true also for the leaves which are reproduced from lopped old trees, and the oil from the seven months' "suckers" contains more cineol and less pinene than that from twelve months' old seedlings, while that from the fifteen months' old "suckers" follows the same rule in respect to the two and a half years' old seedlings. The constants follow this change in constituents somewhat regularly. To a small extent these are governed by the length of time to which the leaves are distilled, as naturally the heavier constituents are brought over with more difficulty. The factors which are influenced to the greatest extent are the specific

gravity and refractive index, and this is noticeable with (*e*) where the idea was to obtain as much of the eudesmol as possible. With commercially distilled oil from mixed leaves of this species there ought to be obtained a product of a fairly constant nature, and this is more readily seen from the results with (*f*) and (*g*). This relative constancy is also illustrated from the results originally obtained in 1898 with material from Monga, N. S. Wales, (over fifty miles from Hill Top), and published in the "Research on the Eucalypts," page 109. The specific gravity of two samples of the oil of this species, distilled at the Technological Museum at that time, but collected on different dates, was 0·915 in both cases; the rotation was $\alpha_D + 6\cdot14^\circ$ one case, and $+ 6\cdot24^\circ$ in the other; both samples were soluble in one and a quarter volumes 70 per cent. alcohol; the saponification number of one sample was 2·4, and of the other 2·9; the cineol in both, determined by the phosphoric acid method, exceeded 70 per cent. These results, when compared with (*f*) and (*g*) above, agree most closely.

The ester content in the oil of this species appears to be higher in that from the "suckers" than in the oil from seedlings; it is not high in any case, although sufficient, perhaps, to somewhat influence the odour.

The dextrorotation of the oil of this species is not entirely due to the pinene, because the eudesmol is also optically active in the same direction; it may be fairly well assumed, however, that the optical activity of the oil gives a good indication of the amount of pinene present.

From the results so far obtained it may be accepted that the first cutting for oil distillation, with cultivated trees of *E. Smithii*, should not take place until the seedlings are three years old. The trees might then be expected to furnish a fresh crop of leaves every two years.

ON THE COMPOSITION OF HUMAN MILK IN AUSTRALIA.[1]

Part I. The Composition during the Early Stages of Lactation.

By H. S. Halcro Wardlaw, B.Sc.

(From the Physiological Laboratory of the University of Sydney.)

[*Read before the Royal Society of N. S. Wales, August 4, 1915.*]

SYNOPSIS.

1. Introduction.

Although the composition of human milk has for many years been the subject of investigation, the number of exhaustive series of analyses which exist to day is very small, and as samples of milk from individual women seem so frequently to have compositions which differ widely from that represented by the mean of the results of the separate analyses of a series, it has proved rather difficult to say what is the significance of these mean or average figures, and from them to lay down a certain composition as being

[1] The work of which this paper is an account was carried out in the year 1914, during the author's tenure of a Science Research Scholarship of the University of Sydney.

that which the composition of any given sample of human milk is most likely to be. This fact is not very generally recognised, although a few investigators have pointed out the indefiniteness of these mean figures, and have despaired of making any general quantitative statement as to the composition of human milk (Hammarsten, Völtz). Other workers, for example Leeds, have endeavoured to give additional value to the mean of the results of their analyses by stating also the highest and lowest figures obtained for the amount of each constituent, and thus indicating the limits between which the variations occurred.

In the following table are given typical sets of figures representing the means of the results obtained for the percentages of the various constituents in series of analyses of human milk. The maximum and minimum values for the amount of each constituent are also given. The examples chosen are from the only three exhaustive modern investigations of the composition of human milk which the present author has been able to find. The original figures of an extensive series of analyses carried out by Adriance and Adriance (1898) unfortunately could not be obtained.

Table I.—*Typical mean, maximum, and minimum figures for the density and composition of human milk.*

	Density.	Total Solids.	Fat.	Solids not fat.	Protein.	Milk Sugar.	Ash.
Maximum	1·0353	16·8	6·9	12·1	4·9	7·9	0·37
Mean	1·0313	13·3	4·1	9·1	2·0	6·9	0·20
Minimum	1·0260	10·9	2·11	6·6	0·85	5·4	0·13
Maximum	1·0426	17·1	8·8	...	4·05	8·9	0·50
Mean	1·0313	12·0	3·07	8·2	1·97	6·6	0·26
Minimum	1·0240	8·6	0·47	...	1·02	4·4	0·17
Maximum	...	13·9	5·8	...	2·04	7·5	0·34
Mean	...	12·0	3·36	8·6	1·35	6·4	0·23
Minimum	...	9·4	1·27	...	0·81	5·35	0·11

The first set of figures is from sixty analyses of the milk of women living in America, carried out by Leeds (1884); the second set of figures is from ninety-four analyses of the milk of women living in England, carried out by Carter and Droop Richmond (1898); the third set of figures is from fifty-three analyses of the milk of women living in Germany, due to Camerer and Söldner (1895, 1896, 1898).

From this table will be seen the amounts to which the percentages of the various constituents of human milk may vary. It will be noticed that these variations are greatest in the case of the fat, and least in the case of the sugar. It will be seen also that the average figure given for the protein-content of human milk by Camerer and Söldner, is considerably lower than that given by the other investigators. The former workers estimated protein by determining the nitrogen of the tannic acid precipitate from the milk and multiplying this quantity by the factor 6·25, the latter workers estimated the protein by the method of Ritthausen (precipitation by means of alkaline copper sulphate, extraction of the precipitate with ether, and direct weighing, or estimation of the nitrogen in it).

Practically all of the analyses of human milk available to the present author were, with the exception of the results of Leeds and of Adriance and Adriance, who analysed the milk of women living in America, of the milk of women living in Europe. In the present communication the results of the analyses of samples of milk from over one hundred European women living in Australia are submitted. A simple application of the theory of probability to these results has been made in the endeavour to arrive at a better defined general quantitative statement as to the composition of the milk examined than is given by the admittedly inadequate method of simply stating the mean, maximum, and minimum values for each constituent. The influence of the

age and of the number of pregnancies of the mother, and of the time of lactation, on the composition of the milk has been studied. The effect of the length of the period of rest which has elapsed since the last withdrawal of milk from the breast and of the volume of the sample, and the difference between the average compositions of the milk from each breast, have also been examined.

The most striking feature of the results obtained is that they seem to give further support to the view that the secretion of the fat of human milk occurs independently of that of the other constituents, since the percentages of the latter show marked tendencies to approach certain "most probable" values, the percentages of fat show not such tendency, but the occurrence of any one percentage within wide limits seems to be no more probable than that of any other.

2. The samples of human milk and methods of analysis.

The samples of human milk of which the analyses are given in this paper were obtained from patients of the Royal Alexandra Hospital for Women, Sydney, through the courtesy of Miss E. M. Buckley, M.B., Pathologist to the Hospital, to whom I express my best thanks.

The patients who come to this hospital for confinement remain there in the ordinary course of events for ten or eleven days after the birth of the child, and of the 105 samples of human milk of which the analyses are given only one represents the milk secreted after a period longer than this after child-birth. The great majority of the samples were obtained four or five days after the birth of the child.

The nurses who obtained the milk were at first instructed to obtain it by massaging the breast of the patient, as a better sample is said to be obtained in this way than with a pump (Engel), but as the nurses seemed to have great

difficulty in collecting samples large enough for analysis by this means, the use of the breast pump was resorted to, and all of the samples except the first two or three were collected with it.

In the case of each sample of human milk the nurses were instructed to record the following particulars:—

1. Age of mother.
2. Number of pregnancies.
3. Age of child.
4. Time of collection of sample.
5. Time of last suckling.
6. Breast from which sample was taken.

The nurses were directed to obtain the whole sample from one breast whenever possible, and to endeavour to empty the breast completely. The samples of milk were collected between 6 a.m. and 9 a.m.; the analyses were begun at about 10 a.m. of the same morning, so that all the estimations were made upon perfectly fresh milk.

Methods of Analysis.—Determinations of density, total solids, fat, and total protein, were made on the samples of human milk obtained. The amounts of solids not fat, and of solids not fat and not protein (chiefly milk-sugar) have been calculated by difference.

The densities of the milks were determined with a pyknometer. The pyknometer used for the first twenty-five samples had a volume of about 8·5 cc., but as the quantities of milk obtained were occasionally smaller than this, a pyknometer having a volume of only about 2·7 cc. was used for the rest of the determinations. The levels of the pyknometer were adjusted after it had hung in a water thermostat for at least ten minutes; the densities given are for a temperature of 25° C. Their values are given to one part in 10,000.

The total solids of the milk were determined on 1 cc. measured from a pipette and evaporated to dryness on a watch-glass in a glycerine oven at 103° C. This small quantity of milk can be spread out in a thin layer on the watch-glass and dries fairly quickly at 103° C. In the calculation of the percentage of total solids the volume of the milk is multiplied by its density to give the weight. The values of the percentage of total solids are given to one part in one hundred.

The fat in the samples of milk was determined by the Röse-Gottlieb (1888, 1891) method. In this method the fat is extracted from the milk mixed with alcohol and ammonium hydroxide by means of a mixture of ether and petroleum spirit of low boiling point, the fat dissolved in this mixture being weighed after evaporating off the spirit. The results of the analyses are given to one part in one hundred.

It has been stated by Radenhausen (1881), Forster (1881), Mendes de Leon (1881), and by others, that the percentage of fat in human milk is lower in the portions first withdrawn than in the portions withdrawn later, and Reyher (1905), Forest (1906), and Engel (1906) have suggested that on account of this fact the whole of the milk contained in the mammary gland should be taken for analysis in order to determine the average percentage of fat in it, or, failing this, that equal portions should be taken for analysis at the beginning and the end of the withdrawal of the sample, the mean of the percentages of fat found in these two portions being taken as the average percentage of fat in the total amount of milk withdrawn. Helbich (1912), who reinvestigated this question later, did not find this dependence of the percentage of fat in human milk on the volume withdrawn from the breast, however. He therefore states that the inverse relation between volume and percentage of fat which Engel claims to have observed, does not exist.

In the present work an endeavour was made to comply with the above recommendations by having the mammary gland emptied as completely as possible for each sample.

It has also been shown by Engel (1910), that the percentage of fat in human milk is lower the longer the interval of time is which has elapsed since milk was last withdrawn from the gland. Account has been taken of this statement in the present case by noting the time which had elapsed for each sample since the last withdrawal of milk from the same gland, with a view to ascertaining whether any similar effect of time on the percentage of fat in the milk secreted was to be observed.

In the case of the cow, the fact that the last portions of a milking are richer in fat than the first is well known, and seems to have been first demonstrated by Parmentier and Deyeux as long ago as 1790. It is also well known to dairymen that the shorter the period of rest between two successive milkings of a cow the richer in fat is the milk yielded at the second milking, but the smaller is the volume obtained.

The total protein in the first fifty-three samples of human milk was estimated by the method of Sikes (1906). In this method, 5 cc. of milk to which two or three drops of a saturated solution of citric acid have been added to hinder the precipitation of salts, are mixed with 100 cc. of absolute alcohol, and boiled. The proteins are completely precipitated, and the fat, sugar, and extractives go into solution in the hot alcohol. The precipitate is spun in a centrifuge while hot and washed twice with 30 cc. of boiling alcohol. In the present case large quantities of absolute alcohol and a centrifuge in which the washing could be done conveniently were not available. The precipitation was therefore brought about by means of 95% methylated spirit, and the precipitate was washed twice with 50 cc. of the

spirit on a filter surrounded by a steam coil which kept the liquid hot. No protein could be detected in the filtrate from this precipitation by means of Millon's reagent. This reagent as used in the present case was capable of detecting one part in 20,000 of protein in solution, a quantity which would amount to about 0·25% of the protein estimated. No sugar could be detected in the second washing by means of Fehling's solution. This reagent, as used in the present case was capable of detecting one part of lactose in 8,000, a quantity which would amount to about 0·2% of the whole of the lactose present. No simple qualitative test for fat of a well-defined order of delicacy was known, but a comparison of the results obtained by this method with those obtained by another method (described below) in which the fat was completely removed from the milk before the estimation of protein showed that the amount of any fat not removed by the washing was within the experimental error.

In samples 71 to 122 a modification of the above method was used for the estimation of protein. Instead of a fresh sample of milk being taken, an aliquot part of the aqueous layer of the liquids obtained in the estimation of fat by the Röse-Gottlieb method was used. The method thus modified has the advantage that the fat and protein are both estimated on the same sample of milk, and that the fat in the liquid in which the protein is estimated has already been completely removed. The quantity of milk required for analysis is in this way much reduced, a determination of both fat and protein being easily made on 5 cc. of milk. Further, it is unnecessary to take precautions to keep the liquids hot during filtration in order to keep fat in solution. The first precipitation must, however, still be made from boiling alcohol, or the precipitate will not come down completely, and hot alcohol is more convenient for the washings than cold. Citric acid was added before the precipitation

as in Sikes' method, but was found later not to reduce the ash-content of the precipitate of protein. The percentage of ash in the precipitates was found to be about five; Sikes found the percentage of protein to be about three in his precipitates, but in the present case the percentage of ash in the precipitates obtained by his method was the same as in those obtained by the method described.

The aqueous layer of the liquids obtained in the estimation of fat by the Röse-Gottlieb method is not clear, but opalescent, owing to the presence of substances in colloidal solution, the chief of which are caseinogen and phosphates. On standing, part of this fine suspension slowly rises and collects beneath the ethereal layer. When this has occurred, the distribution of the substances in the aqueous layer is no longer uniform, so that, in taking an aliquot part of this layer for the estimation of protein, a representative sample might not be obtained, and a fallacious result might be arrived at, although, as the precipitate is probably composed of phosphates which have been thrown down by the addition of ammonia, the effect of this uneven distribution of the contents of the aqueous layer upon the amount of protein found would probably be insignificant. The liquids, however, should not be allowed to stand longer than about one hour, or should be shaken up and allowed to settle again if they have stood too long.

The following protocol of an estimation of fat and protein on the same sample of milk will give a more definite idea of the method outlined above.

Ten cc. of human milk in a 100 cc. stoppered measuring cylinder were mixed with 2 cc. of 10% ammonium hydroxide and 10 cc. of 95% methylated spirit; 25 cc. portions of ether and of petroleum spirit were then added, the mixture being thoroughly shaken after each addition, and finally allowed to stand for about one hour. The levels of the ethereal and aqueous layers were then found to be at 70·6 cc. and 19·0 cc., respectively. The volume of the

ethereal layer was therefore 51·6 cc., and that of the aqueous layer 19·0 cc. Twenty cc. of the ethereal layer were pipetted off and the spirit was driven off in a weighed vessel. The fat which remained behind weighed 0·1257 gm. The percentage of fat in the milk was therefore: 0·1257/10 × 51·6/20 × 100/1·030 or 3·14, the density of the milk being taken as 1·030. Ten cc. of the aqueous layer were now pipetted off and the protein in this liquid was precipitated as described above. The dried precipitate weighed 0·1146 gm. The percentage of protein in the milk was therefore; 0·1146/10 × 19·0/10·0 × 100/1·030 or 2·11.

The following series of estimations of the amount of protein in human milk show the degree of concordance which is attainable between individual estimations on the same sample by this method:

Sample A.	Sample B.	Sample C.
2·62%	3·20%	2·59%
2·63	3·22	2·57
2·60	3·21	2·56
2·63		
2·62		

The results obtained by this method thus agree together to within about 1%.

In order to ascertain whether the results obtained by this method are strictly comparable with those obtained by the method of Sikes, six estimations of the amount of protein in a sample of milk were carried out by each method. The mean result of the six estimations by Sikes' method gave the percentage of protein as 1·36, while the mean of the six estimations by the present method gave the percentage as 1·35. The two methods therefore give closely agreeing results. The percentages of protein are given to one part in one hundred in the accompanying tables.

Of the remaining constituents of human milk, which have not been directly estimated, 90% are made up of milk sugar. The chief other substances present are: ash 0·2%; nitrogenous extractives, principally urea, 0·2%; citric acid

0·05%. The total quantity of these substances is small, so that comparatively large variations in their amount would not materially alter the total amount of these remaining constituents of human milk, and so a reliable estimate of the amount of sugar present may be arrived at by simply deducting 0·5 from the percentage of substances obtained by subtracting the percentages of fat and of protein from the percentage of total solids. In the table of results the percentages of these solids not fat and not protein are given, and from them the percentages of sugar may be calculated by making the above deduction.

The percentages of solids not fat have also been given in the table of results, as this portion of the milk has been observed to be more constant in amount than the other constituents, and importance has therefore been attached to it for purposes of comparison.

3. Results.

The results of the analyses made, and the particulars of the samples of milk used are given in the following table. The figures given in the several columns represent: (1) the number of the sample; (2) the breast from which the sample was taken, R = right breast, L = left breast, B = both breasts; (3) the age of the mother in years; (4) the number of the pregnancy; (5) the age of the child in days; (6) the time in hours since the last application of the child to the breast; (7) the volume of the sample in cc.; (8) the density of the sample; (9) the percentage of total solids; (10) the percentage of fat; (11) the percentage of solids not fat; (12) the percentage of protein; (13) the percentage of solids not fat and not protein. The results given in the table have been arranged in descending order of the number of pregnancies of the mother, the results for any given number of pregnancies being in descending order of the age of the mother and of the time since the child was last suckled.

Table II.—*Results of analyses of human milk and particulars of samples.*

Number.	Breast.	Age of Mother.	Pregnancy.	Age of Child.	Hours since suckled.	Volume of sample.	Density.	Total solids	Fat.	Solids not fat.	Protein.	Solids not fat nor protein.
42	B	14	1	5	1·0	19	1·0297	10·4	2·10	8·3	2·02	8·3
69	R	17	1	4	7·0	15	1·0360	12·3	2·78	9·5	...	...
98	R	17	1	9	1·0	8	1·0291	14·0	3·95	10·0	1·68	8·3
121	B	18	1	5	1·5	31	1·0333	13·0	3·28	9·7	2·26	7·5
67	B	18	1	10	0·5	14	1·0297	13·7	4·32	9·4	...	...
58	R	19	1	4	1·25	26	1·0325	13·6	4·38	9·2	1·81	7·4
101	R	19	1	4	1·75	16	1·0358	10·8	1·09	9·7	1·29	8·4
99	L	19	1	4	3·0	18	1·0327	10·7	1·42	9·3	1·67	7·6
72	B	19	1	9	1·5	24	1·0329	13·2	3·61	9·6	1·53	8·1
78	B	20	1	4	2·0	23	1·0301	14·8	2·55	12·2	1·23	11·0
32	L	20	1	5	2·5	20 –	...	11·9	2·39	9·5	1·87	7·6
60	B	20	1	5	3·25	13	1·0318	13·3	3·85	9·4	2·42	7·0
30	R	20	1	7	7·75	20+	1·0334	11·5	5·26	6·2	1·82	4·4
102	L	20	1	11	0·5	9	1·0320	12·2	5·88	6·3	2·50	3·8
23	R	20	1	5	...	20+	1·0330	13·2	2·98	10·2	2·20	8·0
113	L	21	1	4	1·25	10	1·0372	11·7	1·42	10·3	3·00	7·3
117	L	21	1	4	3·0	9	1·0337	12·2	2·51	9·7	2·41	7·3
44	R	21	1	5	1·0	16	1·0338	12·0	2·71	9·3	2·60	6·7
39	B	22	1	3	2·0	20+	1·0330	12·8	3·14	9·7	2·32	8·3
24	L	22	1	3	7·75	20+	1·0311	13·3	3·87	9·4	2·08	7·3
96	R	22	1	4	3·5	...	1·0331	12·9	3·31	9·6	1·82	7·8
108	R	22	1	7	1·5	20	1·0312	12·8	3·46	9·3	1·35	8·0
46	B	23	1	5	0·5	16	1·0298	12·9	3·44	9·5	2·18	7·3
82	B	23	1	5	11·0	27	1·0332	12·6	2·82	9·8	1·81	8·0
86	B	23	1	6	1·5	15	1·0331	12·5	3·40	9·1	1·73	7·4
93	R	23	1	10	1·0	...	1·0337	12·7	2·52	10·2	1·65	8·4
64	L	24	1	6	0·5	35	1·0344	11·5	1·93	9·6	1·67	7·9
38	B	24	1	3	1·0	20 –	...	10·2	2·21	8·0	2·86	5·1
52	R	24	1	7	0·5	14	...	10·7	2·03	8·7	2·88	5·8
55	R	24	1	18	2·0	8	...	13·7	4·59	9·1	...	...
31	R	25	1	4	0·5	20+	1·0343	12·6	2·86	9·7	2·30	7·4
48	B	25	1	4	6·5	10	...	9·5	0·56	8·9	2·43	6·5
28	L	25	1	8	2·75	20+	1·0308	11·3	2·37	7·9	2·45	6·3
104	B	26	1	3	1·0	9	1·0308	11·2	2·29	8·9	1·66	7·2
103	L	26	1	6	1·0	15	1·0302	12·2	2·78	9·4	1·77	7·6
57	L	26	1	11	1·0	27	1·0238	16·5	7·65	8·8	1·64	7·2
61	L	27	1	4	1·5	22	1·0327	11·8	2·40	9·4	2·32	7·1
76	B	27	1	5	0·5	14	1·0325	9·2	0·73	8·5	1·70	6·8
105	R	27	1	5	1·25	29	1·0312	9·4	1·01	8·4	1·54	6·8
25	R	27	1	5	4·25	20+	1·0318	11·2	2·22	9·0	1·78	7·2
119	L	27	1	8	2·0	11	1·0295	12·9	3·07	9·8	2·01	7·8
114	B	27	2	9	1·0	9	1·0313	12·5	3·23	9·3	1·62	7·6
22	R	28	2	3	2·75	20 –	...	13·1	3·10	10·0	2·02	8·0
109	L	37	2	6	1·0	15	1·0323	13·3	3·46	9·8	1·68	8·2
27	R	...	2	4	4·75	20 –	...	11·2	1·63	9·6	1·97	7·6
34	B	...	2	5	1·5	20+	1·0351	12·6	2·41	10·2	4·00	6·2
66	R	18	2	4	1·0	30	1·0318	11·9	2·86	9·0	1·85	7·2
112	B	18	2	6	5·5	15	1·0301	12·2	3·11	9·1	1·65	7·4
41	L	19	2	3	1·0	20+	1·0324	12·0	3·77	8·2	2·08	6·1
80	L	19	2	4	1·0	23	1·0337	12·1	2·76	9·3	1·28	8·1
45	B	19	2	5	0·5	14	...	12·5	3·87	8·6	2·75	5·9
92	R	19	2	5	2·5	13	1·0351	11·6	1·83	9·8	2·67	7·1

TABLE II.—*continued.*

Number.	Breast.	Age of Mother.	Pregnancy.	Age of Child.	Hours since suckled.	Volume of sample.	Density.	Total solids	Fat.	Solids not fat.	Protein.	Solids not fat nor protein.
68	L	20	2	4	1·75	14	...	12·8	3·20	9·6	...	...
53	L	21	2	4	1·25	17	1·0347	12·2	2·16	10·0	2·70	7·3
95	L	21	2	6	1·5	...	1·0326	11·5	2·25	9·2	1·44	6·7
51	R	22	2	5	0·5	29	1·0332	10·9	1·46	8·4	2·11	7·3
20	L	22	2	5	2·0	20+	1·0295	12·2	1·64	10·6	1·60	9·0
33	L	22	2	2	7·5	20+	1·0344	12·2	2·50	9·7	2·39	7·3
54	L	23	2	4	9·25	28	1·0327	13·5	3·65	9·8	1·96	7·9
71	L	23	2	7	1·0	19	1·0349	11·9	2·05	9·8	1·94	7·9
74	L	24	2	4	5·25	11	1·0336	13·5	3·64	9·9	1·94	7·9
77	R	25	2	4	0·75	13	1·0300	13·2	4·15	9·0	1·92	7·1
115	B	26	2	2	2·0	9	1·0330	13·7	3·48	10·2	2·95	7·3
89	L	26	2	5	1·5	15	1·0310	13·6	4·08	9·5	1·68	7·8
65	L	26	2	5	2·0	24	1·0354	15·5	4·53	11·0	2·55	8·4
70	L	26	2	6	0·75	16	1·0293	14·9	3·14	11·8	2·01	9·7
79	R	27	2	5	1·0	9	1·0340	13·7	3·93	9·8	2·09	7·7
21	L	27	2	5	1·5	20−	...	12·3	2·00	10·3	2·40	7·9
94	L	28	2	5	1·0	...	1·0333	11·8	2·52	9·3	1·68	7·6
19	L	28	2	5	3·5	10+	1·0308	13·6	1·82	11·8	1·10	10·5
100	R	29	2	4	2·75	8	1·0296	12·6	3·48	9·1	3·92	5·2
107	R	30	2	3	1·0	10	1·0353	11·0	...	...	...	...
111	B	30	2	5	1·0	11	1·0324	11·3	2·14	9·2	1·58	7·6
88	R	30	2	5	1·75	9	1·0298	11·6	4·22	7·4	1·30	6·1
120	B	30	2	9	1·5	35	1·0318	13·2	3·91	9·3	1·53	7·8
90	B	30	2	8	1·5	13	1·0335	12·6	2·81	9·8	1·32	8·5
122	L	30	2	8	8·75	20	1·0360	10·8	3·50	7·3	1·43	5·9
62	L	31	2	5	1·0	30	1·0368	13·2	2·48	10·7	3·58	7·1
87	L	32	2	3	3·5	23	1·0329	13·5	2·03	11·5	1·98	9·5
75	L	26	3	4	1·0	15	1·0358	10·8	1·21	9·6	2·44	7·1
29*	R	28	3	2	8·25	20−	...	18·6	2·63	16·0	4·10	11·9
43	B	30	3	4	0·5	22	1·0263	11·8	3·75	8·0	2·60	5·4
97	R	32	3	3	3·0	11	1·0307	13·6	4·12	9·5	1·16	8·3
73	L	34	3	4	2·0	21	1·0332	13·2	3·42	9·8	2·01	7·8
47	B	40	3	7	0·5	27	1·0313	12·9	3·97	8·9	2·04	6·9
50	L	...	3	4	0·5	31	1·0301	9·9	4·14	5·8	2·78	3·0
85	B	26	4	8	1·0	18	1·0305	13·8	4·43	9·4	1·38	8·0
26	L	29	4	8	2·0	20+	1·0307	13·4	3·80	9·6	1·99	7·6
91	R	34	4	9	1·0	12	1·0307	13·7	4·41	9·3	0·99	8·3
59	L	42	4	4	1·0	17	1·0313	11·4	3·66	7·7	1·49	6 2
40	B	33	5	6	3·5	20−	...	12·5	2·86	9·6	1·99	7·6
110	R	26	6	5	3·0	18	1·0343	11·2	1·82	9·4	1·71	7·7
81	B	30	6	4	1·0	12	1·0293	10·0	1·09	8·9	4·20	4·7
83	B	30	6	4	1·5	31	1·0329	12·5	3·80	8·7	2·17	6·5
56	L	30	6	5	0·5	26	1·0325	11·6	1·99	9·6	1·94	7·7
49	L	31	6	6	0·5	20	1·0297	10·6	2·39	8·2	2·30	5·9
118	R	31	6	8	1·0	35	1·0274	12·3	3·87	8·4	2·57	5·9
116	L	32	7	8	0·25	19	1·0318	12·2	2·25	9·9	1·91	8·0
84	B	32	9	9	1·0	11	1·0308	14·5	4·64	9·9	1·87	8·0
63	L	25	multi-para	6	1·0	14	1·0329	13·1	3·38	9·7	2·02	7·7
35	B	18	...	4	1·5	20+	1·0316	10·9	1·77	9·1	3·93	5·2
18	R	21	...	11	3·0	20+	1·0293	11·7	1·52	10·2	0·95	9·2
37	B	20	...	4	2·5	20+	1·0322	11·7	2·53	9·2	1·98	7·2
36	B	24		4	4·0	20+	1·0339	13·0	3·02	10·0	3·21	7·8

* Colostrum.

Although the significance of the mean values of the results of a series of analyses such as the above is in general not so apparent as might be desired, the mean values of the results of the above series have been given, together with the maximum and minimum values, both for comparison with the results of other investigators, and because, as will be shown later, mean values may approach values having a definite significance when the number of observations is fairly large, as in the present case.

Table III.—*Maximum, mean, and minimum values of the density and composition of the samples of human milk examined.*

	Density.	Total Solids.	Fat.	Solids not fat.	Protein	Solids not fat nor protein.
Maximum	1·0370	15·5	7·65	12·2	4·2	11·9
Mean	1·0321	13·1	3·14	10·0	2·00	8·0
Minimum	1·0260	9·4	0·56	6·2	0·95	3·8

The results for sample 29, which was colostrum, are not included in the above table. The figures in the table show how widely separated are the limits between which the composition of the samples of human milk examined in the present case varied. The mean values, it will be noticed, are not very different from those of the investigators quoted at the beginning of the paper, with the exception of the values for the percentage of protein given by Camerer and Söldner (*loc. cit.*), which differ from the values given by the majority of other workers. It must be remembered, however, that the present results are for the milk of the first week of lactation only.

4. The most probable composition of human milk.

When a series of measurements of a certain quantity is made, the results of these measurements are found, in general, not to be identical, but to differ among themselves, even when the quantity measured is assumed to remain

unchanged. Under these circumstances, when the measurements are all made with equal care, there is no reason to believe that any one of them is nearer the truth than any other and the arithmetic mean of the whole number of measurements is taken as representing a value which is probably nearer to that of the quantity itself than the value obtained from any isolated measurement. The arithmetic mean of the results in this case has a very definite meaning.

But when the quantity measured itself varies, each value which it takes cannot be regarded as an equally probable approximation to a hypothetical "true" value, but itself has a real existence. To take the arithmetic mean of a series of measurements of such a quantity, then, is to obtain a figure which only has a meaning on the basis of assumptions which do not hold in this case. As the arithmetic mean of a series of measurements of a quantity which varies has thus, of itself, no significance, how then is a series of measurements of such a quantity to be briefly described? Attention seems to have been first directed to this question by Francis Galton (1879).

Quantities which are observed to vary are of two main types: (1) those whose variations bear a definite relation to the variations of a second quantity or group of quantities, and (2) those in which no such relation to other quantities has been detected. A series of measurements of a quantity of the first type may be briefly and completely described by stating the relation which exists between this quantity and the second quantity or group of quantities. Such a relation is expressed by the mathematical function which the values of the first quantity are of the values of the second quantity. Numerous intermediate stages occur between the extreme cases where all the values taken by one quantity are a function of the values of other quantities and where no definite relation has been discerned

between the values of the quantities associated together. Karl Pearson (1903) has regarded all phenomena as being, to a certain degree, contingent upon one another. In phenomena or quantities of the first type the degree of contingency is high, and may be expressed numerically as approaching unity, where a contingency of 1 represents absolute dependence. In phenomena or quantities of the second type the degree of contingency is low, and may be represented as approaching zero, where a contingency of 0 represents complete independence.

The values of the various quantities which may be measured in milk, the percentages of the various substances which occur in it, although they must *a priori* bear an intimate relation to one another, being produced together by living organism which we know by observations made in other directions to have a wonderful power of co-ordinating its activities, yet do not bear to one another a relation which we have so far been able to accurately and briefly define. The amounts of the different substances occurring in milk must therefore be regarded at present as bearing only a low degree of contingency to one another, and not very much information may be gained by the study of the relation between series of observations of such quantities, as will be seen later.

If, however, each of these series be examined separately, and the results be arranged according to their magnitude, the series may be found to be capable of being divided into two main classes: (1) those in which the numbers of results are fairly evenly distributed over the whole range of the values observed, or (2) those in which there is a certain value in whose vicinity the results are much more numerous than elsewhere, the numbers of results becoming smaller and smaller as this value is receded from in either direction. In a series of results of the first kind, any particular result

is, to all appearances, no more likely to occur than any other, and the values of the results obtained must, on the evidence at hand, all be regarded as equally probable. The only convenient way of summarising such a series of values is to take the arithmetic mean of them all. But the figure obtained by this process cannot be regarded as being likely to be nearer a "true" value of the quantity measured than any isolated result, as in the case discussed above, but is simply a number such that any particular result in the series is no more likely to be above it than below it.

But in the case of a series of the second kind, there is a value in the vicinity of which the results seem to be more likely to occur than in parts of the series further removed from this value. There is thus a greater probability that any result will fall in the vicinity of this value than anywhere else. Such a value may, therefore, be regarded as the most probable value of the quantity which is being observed.

The values obtained for the percentages of the various constituents in the samples of human milk analysed in the present work have been arranged according to their magnitude, as described above, and it has been found that both of these latter types of series are represented among them. In arranging a series of values according to their magnitude for examination in this way, the successive values must be so chosen as to increase by some convenient amount at each step, and in the present case the increment chosen for each step is one-tenth of the mean or most probable value of the series. If the steps chosen be too small, irregularities (not necessarily inaccuracies) in the values of the results obtained will obscure the general trend of the observations, while if the steps be too large, their number will be too few to adequately show the way in which the grouping of the results varies through the series.

In the following tables the percentages of the constituents of human milk are arranged in ascending order of magnitude, and under each value is given the number of results falling between this value and the succeeding one. Since, in the present case, the total number of results is about one hundred, these numbers represent the percentages of the total number of results falling between each pair of values, and may be considered as the relative probabilities of the occurrence of results having these particular values.

(1) *Fat*—The following are the relative frequencies of occurrence of the various percentages of fat observed in the samples of human milk examined.

Percentage of fat	under 1·2	1·2	1·5	1·8	2·1	2·4	2·7	3·0	3·3	3·6	3·9	4·2	4·5 and over
Number of results	5	3	4	9	9	13	10	9	11	8	11	6	6

From these figures it will be seen that in the case of the fat of the samples of human milk examined, the results show no tendency to group themselves about any particular value, but occur with fairly even frequency over the greater part of the values observed. No most probable value for the percentage of fat can therefore be stated from these results, and the only easily obtained figure of general significance for the whole series is the arithmetic mean of the results, 3·14%.

(2) *Protein*—The following are the relative frequencies of occurrence of the various percentages of protein observed in the samples.

Percentage of protein	0·8	1·0	1·2	1·4	1·6	1·8	2·0	2·2	2·4	2·6	2·8	3·0	3·2 and over
Number of results	2	2	7	7	17	18	13	7	9	6	3	1	7

It will be seen from these figures that samples of milk having percentages of protein between 1·6 and 2·2 were

much more frequent than samples having any percentage outside of these limits. About 50% of the total number of results occur between these values and as they are fairly evenly distributed within the limits, their mean value 1·9 may be taken as representing the most probable percentage of protein in the human milk examined.

(3) *Solids not fat and not protein*—The following are the relative frequencies of occurrence of the various percentages of solids not fat and not protein in the samples. Over 90% of this portion of the milk, it will be remembered, is composed of milk-sugar.

Percentage of solids not fat nor protein	3·8	4·5	5·2	5·9	6·6	7·3	8·0	8·7	9·4	1·1
Number of results	3	3	4	10	16	37	19	2	2	3

From these figures it will be seen that samples of milk having percentages of solids not fat and not protein between 6·7 and 8·7 occur more frequently than samples having any percentage outside of this range, and the mean of this range of values, 7·6, may be regarded as the most probable value of the percentage of solids not fat and not protein in the samples of human milk examined. About 60% of the total number of results occur within this range. The closeness with which the results are grouped about a certain value is greater in this case than the case of the percentages of protein.

The values of the percentages of the other portions of human milk which are considered as being of importance, of the total solids and of the solids not fat and are determined by the values of the constituents just given. The percentages of total solids and of solids not fat are given separately below.

(4) *Total solids*—The following are the relative frequencies of occurrence of the various percentages of total solids in the samples examined.

Percentage of total solids	8·3	9·6	10·9	12·2	13·5	14·8	15·1 and over
Number of results	3	12	24	45	15	3	2

It will be seen from these figures that samples of milk having percentages of total solids between 10·9 and 14·8 are of considerably more frequent occurrence than samples having a percentage outside of this range. The mean of this range, 12·8% may therefore be considered as the most probable percentage of solids for the series. The results are even more closely grouped about this value than in the previous case, over 80% of the results occurring within an equal range. These figures also indicate that the occurrence of percentages of total solids above this value is rather less likely than the occurrence of percentages below it, as the numbers of results are not quite symmetrically arranged about the most probable value but lower values are more plentiful than higher values.

(5) *Solids not fat*—The following are the relative frequencies of occurrence of the various percentages of solids not fat observed in the samples of human milk examined.

Percentage of solids not fat	6·3	7·2	8·1	9·0	9·9	10·8	11·7
Number of results	3	6	17	55	16	2	3

These figures show that samples having percentages of solids not fat between 8·1 and 10·8 are much more frequent than those having any percentage outside this range. Nearly 90% of the total number of results occur between these limits. The mean of this range of values, 9·4%, may therefore be considered as the most probable value of the percentage of solids not fat of these samples of human milk. It will be noticed that the numbers of results are much more closely grouped about the most probable value in this than in any of the other cases studied. This is another way of expressing the generally recognised

fact that solids not fat of milk are much more constant in amount than any of the other constituents usually determined.

The distributions of these results over the ranges of values observed are represented graphically in the accompanying diagram. In this diagram the percentage deviations of the results from the most probable value have been plotted as abscissæ, the percentages of the total number of the results showing these deviations as ordinates.

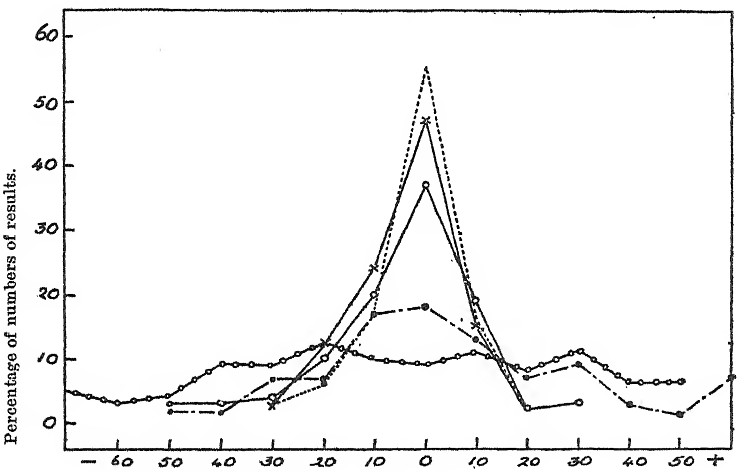

Diagram showing the distributions of the percentages of the constituents of human milk over the ranges of values found.

○——○——○ = fat.
●——-——● = protein.
○————○ = solids not fat and not protein.
×————× = total solids.
– – – – – – – – – = solids not fat.

This diagram shows very clearly how the results tend towards certain values in the case of all of the constituents of human milk estimated, with the exception of the fat. The different degrees of closeness with which the results

are grouped about the most probable values are also well shown by the different heights of the maxima on the curves, and the different degree of steepness with which they rise to these maxima.

The striking difference between the distribution of the percentages of fat and those of the percentages of the other constituents is not peculiar to the present results, but is equally well shown by the results of Leeds, Carter and Droop Richmond, and Camerer and Söldner already quoted in this paper. The following are the relative frequencies of occurrence of the various percentages of fat recorded in their papers arranged as described above. In these cases, of course, since the total numbers of results are not one hundred, the numbers given do not represent percentages.

Per-cent. of fat.	1·5 and under	1·8	2·1	2·4	2·7	3·0	3·3	3·6	3·9	4·2	4·5	4·8	5·1	5·4 and over
Number of results	*1	3	2	5	6	6	9	7	2	5	3	0	2	1
	†0	0	3	3	6	6	2	7	5	5	3	4	0	13
	‡16	6	6	10	6	11	9	9	7	3	3	2	1	4

* Camerer and Söldner. † Leeds. ‡ Carter and Droop Richmond.

As will be seen from these figures, the results show practically no tendency to group themselves about any particular value but occur with fairly even frequency over a wide range of values.

When, however, the percentages of the other constituents are arranged in the same way they are found, as in the case of the results of the present work, to group themselves about certain values with varying degrees of closeness.

The process by which the fat of human milk is secreted, therefore, unlike the processes by which the other constituents are produced, does not seem to favour the appearance of milk containing any particular percentage more than any other between certain wide limits. Although it might be contended that the irregularities found in the

percentages of fat in human milk may be due to a faulty method of obtaining the samples, it seems fairly evident that the fat of the milk is secreted by a process which is more less independent of that by which all the other constituents are produced, and the samples obtained for analysis must surely be comparable with the samples obtained by a suckling child, which can hardly be regarded as regulating to a nicety both the intervals between its meals, and the quantities which it takes. The chief object of the analysis of human milk is, after all, to ascertain the composition of the food of the human infant.

In the table given below the values for the most probable percentages of the various constituents of human milk obtained from the results of the present work and from those of the work of the authors quoted are placed together. The values of the mean percentages are also given for comparison.

Table IV.—*Most probable and mean values of percentages of constituents of human milk.*

Author.	Total Solids.		Solids not fat		Protein.		Sugar.	
	Mean.	Most probable.	Mean.	Most prob.	Mean.	Most prob.	Mean.	Most prob.
Leeds	13·3	13·0	9·1	9·3	2·0	2·0	6·9	7·1
Carter and Droop Richmond	12·0	11·7	8·9	8·6	2·0	1·7	6·6	6·9
Camerer and Söldner	12·0	12·0	8·6	8·7	1·4	1·1	6·4	6·7
Halcro Wardlaw	13·1	12·8	10·0	9·8	2·0	1·9	7·4	7·1

From the above table it will be seen that the results obtained in these four series of analyses, with the exception of the percentage of protein given by Camerer and Söldner, do not differ materially from one another. It would appear, therefore, that climate has no very marked effect on the composition.

These figures show also that the mean values of the results do not differ much, as a rule, from the most probable values. This is due to the fact that the results lying outside the range of most probable values are fairly evenly distributed on either side, and so balance when the arithmetic mean of the whole is taken. The arithmetic mean of series of analyses such as these, although of itself it has no meaning, thus lies close to a value which has a definite significance, and the mean value may, therefore, be used in many cases instead of the better defined, but not so readily accessible, most probable value. It should be remembered, however, that the occurrence of a number of very high or low values in a series of results would considerably alter the mean of the series, but not the most probable value.

5. Variation of composition with time since parturition.

The composition of a sample of human milk is known to depend on the stage of lactation of the woman from whom it is obtained (Schloss, 1912; Camerer and Söldner, Engel, Adriance and Adriance, *loc. cit.*). The main features of this dependence are that the ash and protein of the milk tend to decrease as the lactation continues, while the amount of milk sugar slightly increases. These statements apply to the very gradual alteration in the composition of human milk during the course of months of lactation. During the first few days of lactation, however, the alteration in the composition must be very much more rapid, since the milk first secreted after the birth of the child, the colostrum, has a composition which differs considerably from that of the milk secreted later, the principal difference being the high percentage of protein in the former. Sample No. 29, Table II, is a typical example of colostrum. The variation of the composition of human milk obtained in the first few days after the colostral period, which

normally does not last longer than forty-eight hours, does not seem to have been examined in detail. Practically all of the human milk, the analyses of which are given in this paper, were obtained during this immediately post-colostral period, and the results of these analyses have been arranged in the following table so as to indicate how the average composition alters during these first few days of lactation. The samples from which the table has been compiled were obtained from women who had been suckling for periods ranging from two to eleven days.

Table V.—*Variation of composition of human milk with stage of lactation.*

Suckling for	Number of samples	Density.	Total solids.	Fat.	Solids not fat.	Protein.	Solids not fat nor protein.
1 – 2 days	3	1·0337	14·8	2·84	12·0	3·30	8·7
3 – 4 ,,	39	1·0322	12·2	2·84	9·4	2·33	7·0
5 – 6 ,,	36	1·0320	12·2	2·64	9·6	2·06	7·5
7 – 8 ,,	13	1·0319	12·3	3·27	9·0	2·02	7·0
9 – 11 ,,	11	1·0308	13·5	4·13	9·4	1·69	7·7

It will be seen from this table that the average values of the density and protein fell during the period of observation; the fat remained almost constant for a time and then rose considerably; the amount of total solids fell rapidly at first, this fall being due to the large decrease in the amount of protein associated with the disappearance of colostrum, then rose again as the amount of fat present increased; the amount of solids not fat fell rapidly at first, and then fluctuated slightly, but did not move steadily in any direction; the amount of solids not fat and not protein varied in the same way as the amount of solids not fat. On the whole the composition did not alter materially after the second day. The author hopes to deal with the later stages of lactation in detail in a subsequent paper. The

great majority of the samples dealt with in the present paper were obtained four to five days after the commencement of suckling.

6. Effect of age of woman on composition of milk.

In the samples of human milk which Leeds (*loc. cit.*) examined, he found that the average composition of the milk of women under twenty years of age showed higher values in the amount of every constituent than the milk of women over twenty years of age. In the following table the average compositions and densities of the human milks examined in the present investigation are arranged according to the ages of the women from whom they were obtained. The samples obtained from primiparæ have been kept separate from those from multiparæ.

Table VI.—*Effect of age on composition of human milk.*

	Primiparæ.			Multiparæ.		
Age.	20 and under.	21 to 30	31 and over	20 and under	21 to 30	31 and over
No. of results	15	28	1	8	37	12
Density ...	1·0319	1·0323	...	1·0326	1·0319	1·0314
Total solids ...	12·4	12·2	13·3	12·1	12·9	12·4
Fat	3·15	2·67	3·46	2·87	2·98	2·97
Solids not fat	9·4	9·5	9·8	9·2	9·9	9·4
Protein ...	1·91	2·06	1·68	1·88	2·40	1·96
Solids not fat nor protein	7·7	7·1	8·1	7·3	7·5	7·4

No very clear evidence of a definite relation between the age of a woman and the composition of the milk secreted by her seems to be shown by the above figures. There is some evidence, however, that the percentage of protein is higher in the milk of women between the ages of 20 and 30 than in the milk of women younger or older than this in the case of primiparæ as well as in that of multiparæ.

7. Percentage of fat in milk of each breast.

It has been supposed by certain investigators that there is a constant difference between the average percentages of fat in the milk obtained from each breast. Mendes de Leon (*loc. cit.*) states that the milk of the right breast is richer in fat than that of the left, while Zappert and Jolles (1903) found the milk of the left breast to contain up to 0·6% more fat than that of the right breast. The samples of milk examined in the present case have been compared together to determine whether any such difference between the secretions of the two breasts is to be seen in them. All of the samples compared were of the milk secreted at the same stage of lactation (4 – 5 days *post partum*). The average percentage of fat in the milk of the right breast (19 samples) was found to be 2·57; the average percentage of fat in the milk of the left breast (22 samples) was found to be 2·50. In view of the large variations in the percentage of fat in the samples of human milk examined, however, the difference between these two figures (0·07%) is too small to justify a conclusion that the average percentage of fat in the milk of one breast is persistently higher than that of the milk of the other breast.

8. Effect of number of pregnancies on composition of human milk.

In the following table are given the average values of the density and composition of the milk of women at the first, second, third, and subsequent pregnancies.

Table VII.—*Effect of number of pregnancies on composition of human milk.*

Number or pregnancies	1	2	3	More than 3
Number of samples ...	46	33	20	13
Density	1·0324	1·0328	1·0312	1·0309
Total solids	12·2	12·6	12·6	12·5
Fat	2·91	3·04	3·44	3·32
Solids not fat	9·4	8·6	8·1	9·1
Protein	2·01	2·14	2·17	1·89
Solids not fat nor protein	7·4	6·4	6·4	7·2

From this table it will be seen that the average density is highest at the second pregnancy, and falls as the number of pregnancies increases; the average percentage of total solids is slightly lower at the first pregnancy than at the subsequent; the average percentage of fat rises till the third pregnancy, and then begins to fall; the average percentage of solids not fat is higher at the first than at subsequent pregnancies, although there is a rise after the third; the average percentage of protein, like that of the fat rises, until the third pregnancy and then falls; while the average percentage of solids not fat and not protein, falls after the first pregnancy, but increases again after the third.

9. Effect of volume of sample and of period of rest on fat-content of human milk.

With regard to the effect of the volume of a sample of human milk obtained from the breast one might expect from the work of Engel and others quoted in this connection that, in general, the smaller the volume of a sample was the higher the percentage of fat in it would be. In the present case, when the volume of the sample was between 15 cc. and 24 cc. the average percentage of fat was 2·66; and when the volume of the sample was between 25 cc. and 35 cc. the percentage of fat in it was 3·09. These figures are more in accord with the statement of Helbich (*loc. cit.*) than with that of Engel, and show no very evident reciprocal relation between the volume of the sample and the percentage of fat in the milk.

The effect of the time of rest since the last withdrawal of milk from the mammary gland on the percentage of fat in the milk yielded should be similar, according to the workers cited above, to that of the volume of the sample, that is, the relation should be an inverse one. When samples of milk of approximately equal volume, but obtained

after different periods of rest, were compared in the present case, it was found that after half an hour the percentage of fat was 3·07; after one hour it was 2·95, and after that fluctuated irregularly. No definite relation between the time of rest of the mammary gland and the percentage of fat of the milk yielded is apparent, therefore, from these results.

10. Summary.

1. Certain values of the percentages of constituents other than fat of human milk of the first week *post partum* occurred much more frequently than others. These values were:—total solids, 12·8; solids not fat, 9·8; protein, 1·9; solids not fat and not protein, 7·6.

2. There was no definite percentage of fat, near which the percentages in the majority of the samples lay, but the results were fairly evenly distributed over the whole range of values found. The average percentage of fat was 3·14.

3. The average percentage of fat increased from 2·84 to 4·13 during the first eleven days of suckling; the average percentage of protein decreased from 3·30 to 1·69 during the same period.

4. The age of the woman, the number of pregnancies, the volume of the sample, the time since the last withdrawal of milk from the breast, and the breast from which the sample was taken, appeared to have no distinct effect on the composition of the milk examined.

5. A new method for the estimation of protein in milk has been described.

In conclusion, I wish to express my thanks to Professor Sir Thomas Anderson Stuart, in whose laboratory this work was carried out, and to Dr. H. G. Chapman for his advice and helpful suggestions.

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NOTES ON AUSTRALIAN FUNGI, No. II.
PHALLOIDS AND GEASTERS.

BY

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With Plates XXIV and XXV.

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PHALLOIDS.

In 1907 C. G. Lloyd of Cincinnati wrote a most excellent account of the Phalloids of Australasia, and in 1909 a 'Synopsis of the Known Phalloids.' In these papers the account of the Phalloids in Cooke's 'Handbook of Australian Fungi,' is critically reviewed and the number of species recorded for this continent materially reduced. Having a considerable number of Phalloids under our observation, either in our private collections or in the National Herbarium, we have in this paper recorded notes concerning them which in some respects supplement Lloyd's accounts. In addition, we append a list of the species given by Cooke with their diagnoses as collated from Lloyd's work, as well as a new list of the Australian Phalloids which may be accepted as replacing that compiled by Cooke.

Phallus rubicundus var. *gracilis*, (69, p. 8, fig. 5). Syn. *Phallus novæ-hollandiæ* Corda (40), *Ithyphallus novæ-hollandiæ* Cooke (37 No. 1184, fig. 98), *Cynophallus Caylei* Berk. in F.v.M. (104 p. 119), *Phallus libidinosus* Caley (MS.) Cooke (33, p. 57).

In the National Herbarium, Sydney, there is a fine collection of specimens of this species collected at Campbelltown State Nursery by Mr. J. H. Maiden, in December, 1900, and also two specimens from Grafton collected by Mr. Heinreich in December, 1913. Lloyd suggests (69, p. 8) that *Phallus vitellinus* F.v.M. (Fragm. 7, p. 122) and also *Ithyphallus atrominiatus* Bail. belong to this species.

Phallus indusiatus Vent. Syn. *Dictyophora phalloidea* Desv. in Cooke (37, No. 1175) and *D. tahitensis* Schlecht. of F.v.M. (104) and Cooke (37, No. 1176).

We have specimens of this species from Neutral Bay collected by Dr. E. A. D'Ombrain, spores $4{\cdot}2 \times 1{\cdot}2\mu$ and from Fiji, collected by D. J. North in March, 1908. It had previously been recorded from Richmond River by F. v. Mueller (*l.c.*) and from Booyong by Jackson (54). Also on the Endeavour River and at Brisbane, Lloyd (69, p. 4).

Phallus multicolor Berk. and Br. (25, p. 67, t. xiv, fig. 16), Lloyd (69, p. 6). Syn. *Dictyophora multicolor* Berk. in Cooke (37, No. 1178).

According to Lloyd (*l.c.*) the type specimen of this plant is in the British Museum. It was collected at Brisbane by the late Mr. F. M. Bailey. Our specimen was collected in a moist spot in sandy soil at Ballina, near Lismore, by Miss R. Rothwell in April, 1910, and agrees exactly with the description and illustration given by Lloyd.

Mutinus curtus Berk. (13), Lloyd, (69, 70), Cooke (37, No. 1188). Syn. (?) *Mutinus papuasius* Kalch. (55), Lloyd (69, 70), Cooke (37, No. 1189).

Of *Mutinus curtus* Lloyd says (in 1907) that the description is based on a single collection made sixty years ago by Drummond. It impressed him as based on undeveloped plants and the figure given by Corda (which he reproduces) he thinks is largely imaginary, and he can see no warrant

for the *lobed* volva. Of *Mutinus papuasius* he states that the plant is only known from Kalchbrenner's figure (reproduced), which was made from specimens sent him by Mueller. He adds that it is not really known whether the plant is a *Mutinus* or a *Phallus*, and that if it is a *Mutinus* it is the most slender species known.

Although these two figures appear at first sight to represent quite different plants, we have collected on two occasions a *Mutinus* which, in certain stages of its development, could be represented by either figure (with certain reservations), whilst the mature fungus might figure as a third species. From the comparisons of our specimens with the figures we have little doubt that one species is alone involved which approaches *Mutinus bambusinus* in general appearance, but is best called, at present at any rate, *M. curtus*. The explanation of the figures seems to be as follows: At an early stage within the volva, the receptacle is drumstick shaped, consisting of a delicate white stem capped by a relatively large dull sage-green knob; which elongates later. The apex of the knob is white, the gleba being here deficient, and has a well-marked ostiolum. Both these features are clearly shown in the figure of *M. curtus*, as is also the elongated gleba-bearing knob. The stem is also attenuated downwards but is thicker than in our specimens. The figure is so evidently diagrammatic, however, that this may be overlooked, whilst the five 'lobes' of the volva suggest either the artificial cutting of the closed volva to expose the contents or the delineator's idea of what it would have been had it ruptured in the course of growth. The figure of *M. papuasius* (reproduced in Cooke's Handbook of Australian Fungi, fig. 99) very closely resembles our plants, especially if the stem were considerably shortened. As the figure was drawn from specimens sent to Kalchbrenner which, if our contention is right, had not yet

emerged from their volvas, it is quite reasonable to suppose that the artist would be directed to represent the plant as it would be supposed to appear at maturity, an elongation of the stem being the result. In reality, however, as the plant matures the whole stem enlarges rapidly, becoming more or less uniformly cylindrical but tapering at the summit, whilst its upper half is covered with the gleba.

In further support of the view we hold, that our plants belong to the same species as the two mentioned, it is pointed out that we have obtained it on rotten wood on two separate occasions in different localities on the Blue Mountains, suggesting that it is not an uncommon species, and is therefore likely to have been described. Further, when collected all the specimens were immature, one only emerging during the night from its volva showing how different the adult was from the immature form—immature specimens being, therefore, those most likely to have been collected.

The description of our specimens is as follows:—The 'egg' is more or less globular. On being opened at an early stage, there appears a very slender white stem ($\frac{3}{16}$ in. long), slightly attenuated downwards, capped by a globular slightly rugose dull sage-green head ($\frac{1}{3}$ in. high) having a white apex with a minute ostiolum (the sage-green material being the gleba, the white apex a portion of the stem free from this). Later, when the stem and its head are half-an-inch high, the two together form an elongated inverted cone, the basal half being white and vaguely transversely rugose, whilst the distal half except at the apex is slightly rugose, being covered with the dull sage-green gleba, the apex itself being slightly raised and with a marked ostiolum. Covering the gleba is an obscure wide-meshed whitish network, such as may be seen on opening a *Clathrus* egg, attached to the jelly-like material where this came in contact with the

folded branches and contained gleba, though in the *Mutinus* the network adheres to the gleba and not to the jelly. On removing the gleba from the *Mutinus* at this stage, the hollow stem is found to be attenuated both ways, though more rapidly constricted at the apex, whilst the part covered by the gleba is pale reddish, the rest of the stem being whiter.

When mature, the whole of the stem is about 1 in. high, the basal half being slightly rugose and whitish. The distal half is of the same size at the junction of the two and attenuates slightly to the blunt apex, in which is a minute orifice. This portion is also somewhat rugose and is slightly yellowish, being wrapped round in its lower part by the dull greenish gleba which has fallen away from the apex. Spores $3{\cdot}5 \times 1{\cdot}8\mu$.

On a rotten fallen log, Mount Wilson, N.S.W., June 1915. Also immature specimens on a trunk from Kurrajong Heights, N.S.W., Oct.

Jansia rugosa Lloyd (70), Cheel (27). Syn. *J. truncata* McAlp. in Lloyd (84).

We have specimens in our collection from Rookwood, N.S.W., collected by Mr. A. G. Hamilton, which have been already recorded by one of us (E. C.). These when fresh were noted to have a whitish receptacle slightly tinged pink, gradually deepening into crimson near the apex, with a band of purplish-coloured gleba about a quarter of an inch from the extreme tip. One of the specimens was photographed when fresh by Mr. Hamilton (Plate XXV, *h*). This was reproduced by Lloyd (*l.c.*) who says (93):—"There is no real difference between *J. truncata* of McAlpine and *J. rugosa* on which a species may be based, but the Australian plant is so much larger and more robust and its truncate apex is so much more prominent that it is well

entitled to a name as a form." In addition to the Rookwood specimens, we have also collected examples of this species on several occasions in November and December, 1914, growing, after heavy rain, on a shady sloping bank near a watercourse at Mosman, Sydney. The spores measured $3 \cdot 4 \times 1 \cdot 5\mu$.

Lysurus Gardneri Berk. (14, p. 535, t. xvii, f. 2).

We have a fine series of specimens which we prefer to place under the above specific name, as the fine photographs together with notes on the specimens examined and recorded by Lloyd (69 and 70) clearly show that this is a very variable species and will embrace all the Australian forms described under the following names:—*Lysurus australiensis* Cooke and Massee (35, p. 6), Cheel (28, p. 396); *L. tenuis* Bailey; *Mutinus sulcatus* Cooke and Massee (34); *M. pentagonus* Bailey (3, p. 35), and *M. pentagonus* var. *Hardyi* Bailey (8, p. 494).

In October, 1906, two specimens were collected by one of us (E. C.) at Penshurst. The receptacles or columns were of a whitish colour and measured two and a half and three and a half inches long respectively, being about three quarters of an inch thick in the upper part and tapering slightly in the lower part. A complete volva was secured with one of the specimens which measured about $1 \times 1\frac{1}{4}$ inch, opening at the apex by an irregular rupture and not into definite lobes as depicted in some of the published illustrations of Phalloids. The largest specimen had seven distinctly free lobes and the smallest specimen had six lobes, also free, and in both specimens the inner sides of the lobes were covered with a gleba of a bronze-green colour containing the spores which measured $3 \times 1\mu$. The outer parts of the lobes were more or less fluted or channelled and somewhat notched on the margins. Some specimens collected in the Botanic Gardens have the five arms or lobes

free, while one specimen from the same group of plants has six lobes, four of which are free and the other two united at the apex by a thin membrane, which gives the specimen a somewhat clathrate appearance.

A solitary specimen has also been collected at Woolwich near Sydney, which has three free lobes, whilst the other two are consolidated at the apex as shown in the accompanying Plate XXIV, (*a*). In a group of specimens collected at Killara, six volvas were clustered together, almost cohering at their sides, five of which were expanded whilst the sixth was unopened. In examining the specimens it was found that three of the receptacles had six lobes, one of which had two lobes just united at the apex by a thin membrane, whilst one specimen had seven lobes, and two had five lobes quite free. The specimen with seven lobes was in the unopened volva which was cut and photographed as shown in Plate XXIV, (*b*). A solitary large specimen collected at Wahroonga is fully four inches long and from three-quarters to one inch thick. This has five distinctly free lobes and three smaller ones consolidated somewhat at the margins but free at the apex.

The spores of a specimen collected on the Hawkesbury River are elongated, $4 \times 1{\cdot}8\mu$. It is interesting to note in making a transverse section of one of the specimens collected at Killara, that the receptacle or stem is quite hollow or tubular in the centre, but is distinctly cellular in the outer part. In the fine series of specimens photographed by Lloyd (82, p. 407, fig. 243), a transverse section is shown with a single row of cells in the outer structure. In our specimens a drawing (Plate XXIV, c) made by Miss M. Flockton shows the structure to have at least two distinct rows of these cells. It is quite probable that in the smaller specimens the structure would contain a single row, whilst in the larger specimens two or even more rows of cells will be found.

The following is a list of the collections of this species contained in the National Herbarium, Sydney:—

Killara (H. Selkirk, March, 1905);
Penshurst (E. Cheel, October, 1906);
Wahroonga (Dr. Eric Sinclair, April, 1907);
Botanic Gardens (W. F. Blakely, June, 1908);
—— (W. Challis, April, 1910);
—— (E. Bennett, 1911);
Woolwich (F. Smith, June, 1908);
Milson Island, Hawkesbury River (J. B. Cleland and E. Cheel, July, 1912);
Cronulla Beach (E. Breakwell, 1912);
Campsie (J. Nichol, April, 1912);
Hawkesbury Agricultural College, Richmond (C. T. Musson, 1914);
Neutral Bay (C. Thackeray, May, 1915).

See Cooke (37, No. 1198), Cheel (26, p. 159 and 204) and Musson (106) for previous records.

Anthurus Archeri. Syn. *Lysurus Archeri* Berk. (16, p. 264) figured in the same work on plate clxxxiv, as *L. pentactinus; Anthurus aseroeformis* Cheel (28, p. 607).

The following also appear to belong to this species:— *Aseroe lysuroides* Fischer and *Lysurus aseroeformis* Corda of Cooke (37, No. 1202); *Anthurus Muellerianus* Kalchb. var. *aseroeformis* Fischer (52, fig. 136, f. and g.); *Anthurus aseroeformis* McAlpine in Lloyd (70, fig. 46 and 83, fig. 244); *Pseudocolus Archeri* Lloyd (94 and 95); *? Aseroe rubra* var. *pentactina* Endl.

In the National Herbarium collection there are specimens which when opened out of the unexpanded volva show the lobes slightly incurved and somewhat cohering at the apex but yet quite free and the tips of the five lobes very shortly bifid as shown in the figure of the original specimen figured by Berkely (*l.c.*). We have also a fully developed

specimen which one of us recorded under the name *Anthurus aseroeformis* (28, p. 607) from Mount Royal near Scone. This specimen has five lobes, two of which are slightly united at the apex with a thin membrane, whilst the others are quite free, as shown in Plate XXV, (*i*).

From Yarrowitch near Walcha, some fine specimens were collected by Mr. G. W. Broughton which agree exactly with the description drawn up by Mr. D. McAlpine and published with a photograph by Mr. Lloyd (70, fig. 46 and 82, fig. 244).

We have carefully compared the above specimens, together with another for which no specific locality is given, but which was probably collected by Mr. A. Grant, with the photograph of the specimen collected in a garden at Melbourne, Victoria in April 1907 by Mr. C. French, and communicated to Mr. C. G. Lloyd and referred to above, and have come to the conclusion that they all belong to the same species. The colour of our specimens was of a reddish tint. They were all five lobed, the lobes being more or less channelled on the outer side and convex on the inner side, and either entire and obtuse or very slightly bifid in one specimen at the apex. In addition to the above we have a sketch together with a description of a fungus collected at Squdgy Creek near Bulli Pass in October, 1903, by Mr. W. Benson, which seems to belong to this species.

Mr. Benson's description is interesting and may be given in full as follows:—

"It is what (if such a thing were possible) might be called a flowering fungus. Habitat, Squdgy Creek near Bulli Pass. Appearance a five-rayed starfish. Tips raw-meat-purple, paler pink towards the centre, and the tube nearly white. Down the centre of each ray, some brown slime which appeared to be part of the plant (but the whole place was muddy). Surface of the "flower," rough, like a sheep's tongue. On picking the "flower"

it came away complete, leaving a cup in the ground. But the "flower" immediately collapsed and broke to pieces in my hand. Its substance was almost structureless jelly, nor could I see any pistil, stamens, or other organs. The rays were of the same thickness, perhaps one-eighth inch. The cup was like a puff-ball or young potato in colour, of a tough jelly consistency, and strengthened by internal perpendicular partitions; a thin skin peeling here and there enclosed the cup. From a pimple underneath, two white threads of roots sprang. Unfortunately in scrambling out of the rough spot where I found it, it fell and got lost."

The sketch drawn by Mr. Benson leaves no doubt in our minds that his plant belongs to this species, as it compares very well with a photograph (Plate XXIV, fig. *i*) taken from a specimen collected at Mount Royal Range, on the edge of a swamp at an elevation of about 4,500 feet above sea level, by Mr. H. V. Haynes, in April, 1910. A description of the specimen collected by Mr. Haynes may be given as follows: Volva $1\frac{1}{4} \times 1$ inch in diameter. Receptacle on a short stipe protruding about half an inch from the volva and then dividing into five lobes, each of which is about two and a quarter to two and a half inches long, and of a bright red colour towards the tips, getting gradually paler or almost white towards the base. Lobes coarsely reticulated, the reticulations or rugæ very unequal. The inner parts of the lobes somewhat convex and more or less covered with the dark bronze or greenish coloured gleba, the outer part of the lobes concave. Spores somewhat cylindrical, 5 to 7 $\times$ $2\frac{1}{2}$ to 3μ. Specimens have apparently been seen at Port Macquarie, as Mr. G. A. Waterhouse in a pencil sketch of a fungus seen by him there seems to indicate that it was this species.

Aseroe rubra Labill. (63), Cooke (37, No. 1201), Cheel (26, p. 204). (See Plate XXIV, *a* and XXV, *g* and *j*)

This interesting species was originally collected in Tasmania by La Billardiere, who published a description together with a figure in the year 1798.

Since this date there have been no less than ten species of the genus described, but it is very doubtful if more than three distinct species will stand when the whole of the material collected has been properly investigated and compared with fresh specimens. The following is a list of the names of those species which have been recorded for Australasia in addition to the original *A. rubra*:—*A. actinobala* Corda; *A. pentactina* Endl.; *A. Muelleriana* Lloyd; *A. lysuroides*; *A. Hookeri* Berk.=*A. viridis* Berk.; and *A. poculiformis* Bail.

In addition to the above there are four species found in other countries, the names of which are as follow:—*A. zealandica* Berk., a native of Ceylon; *A. junghuhnii*, common in Java; *A. pallida*. a native of New Caledonia, and *A. arachnoida* Fischer.

The last mentioned species is a native of Cochin China and Java and seems to be quite distinct from any of the Australian forms. *A. zealandica* seems to be very little different from the Australian species and has been regarded as a variety of *A. rubra* by some authorities.

In the National Herbarium of Sydney, there are five dried specimens collected in Tasmania near the type locality by R. C. Gunn, who has written the following remarks concerning them on the sheets with the specimens:—"*Aseroe rubra*? Labill.—I saw it abundantly, February 1851, growing in light decomposed vegetable matter in a dense forest of *Fagus Cunninghamii*. It bursts out of a ball like *Ileodictyon*. Colour very bright crimson, smells like tainted meat. The centre of each was full of blackish or brown slimy matter. Very brittle and not easily dried."

Two of these specimens have nine bifid lobes, one has seven bifid lobes, and a fourth specimen is too imperfect for examination. On another sheet, a very large specimen is mounted with the following remarks, also in Gunn's handwriting:—"*Aseroe rubra*? Labill. I annex observations to the other specimens sent herewith. This genus is obviously closely allied in many points to *Ileodictyon*. La Billardiere's figure is so bad that it is not easy to identify the species by it, but as the country where he gathered his original specimen formed a dense *Fagus* forest, it is probably the same, yet he says in his Voyage, the whole surface of the *Aseroe rubra* is smooth, whereas this one is *not*. I send you specimens in spirits." Gunn's specimens were sent to Hooker who handed them over to Berkeley for determination. It is evident that this species has attracted the attention of several collectors in New South Wales also, for we find it frequently mentioned in Berkeley's early works on Fungi. It was collected near Sydney as far back as 1844 by Leichhardt, who forwarded specimens to Berkeley. Other collections were also made near Sydney as will be seen from the following observations by Berkeley who also published a figure (12):—

"This singular fungus was found in the Government demesne by Lieut. Lynd, Barrack Master at Sydney, growing early in April on rotten wood, not fifteen yards from the seawards."

Specimens recorded from other localities by Berkeley (18) are as follows:—Dandenong, Victoria (Boyle); New England, N.S. Wales (C. Stuart); Lake Gillies (J. Stuart). Berkeley published the following remarks concerning these latter specimens:—

"Amongst rubbish left by river-floods. Very fugacious. In all these specimens the rays are bifid only at the very extremity; spores ·0003 in. long. Dyes the fingers when fresh, but the colour is very fugacious."

In the same paper, Berkeley mentions *A. pentactina* Endl. from New England, Timbarry (C.M.) and makes the following remarks:—

"Hymenium distinctly rugose as stated by Corda; but this is also the case in the Dandenong specimens which I at first thought might be distinct. R. Brown was inclined to an opinion that all the Australian specimens were referable to a single species."

We have not seen this latter species but as the specific name *pentactina* implies that the specimen has five lobes, and Berkeley states that "the rays are bifid only at the very extremity, it would seem that this is nearer to the genus *Anthurus* than to *Aseroe*, and may possibly be the same as *Anthurus Archeri*. According to Lloyd (Mycological Notes, No. 32, p. 424) the species extends to New Zealand, as specimens are represented in the Museum at Upsala, which were collected there by G. von Scheele and Berggren.

The most common form in New Zealand is one originally called *Aseroe viridis* by Berkeley who afterwards named it *A. Hookeri*. This appears to be a very small plant according to the descriptions and figures given by Berkeley and Lloyd, and is very similar to, if not identical with, a solitary specimen in our collection from Nundelong Road, Balmoral, collected by Mr. Bragg in June, 1902. The specimen is much smaller than the normal forms of *A. rubra*, and has six bifid rays, but unfortunately there are no colour notes with the specimen, so that we prefer to regard it at present as a form of *A. rubra*.

In the National Herbarium there is a splendid collection of specimens, mostly preserved in alcohol or formalin. The following is a list of the localities where these were collected, together with the names of the collectors and date of collecting:—

New South Wales—Byng, near the Canoblas (no collector given, July, 1893);
Peakhurst (W. Buckingham, June, 1899);
Turramurra (H. G. White, June, 1900);
Clyde Pottery, Camperdown (Mrs. McArthur, April, 1903);
Penshurst (E. Cheel, April, 1907);
Killara (W. Benson, March, 1907);
Woollahra (H. Waters, November, 1909);
Raydon near Dural (R. Turner, January, 1911);
Parramatta (A. Thompson);
Chatswood (Booth, March, 1911, and Gilfillan);
Lismore (Miss Rothwell, October, 1900);
Rookwood (A. Spencer, July, 1910, photographed by Mr. A. G. Hamilton);
Weston (V. Davis, 1912);
West Maitland (Miss Cranch, 1912);
North Sydney (Dr. H. I. Jensen, 1912);
Neutral Bay (J. B. Cleland, May, 1914).

There is extreme variation in the size as well as in the general structure of the specimens as will be seen from the following remarks:—The specimens from Turramurra have eight lobes, all of which are bifurcate at the tips. There are two specimens from Lismore with six lobes, and one with seven lobes. Two specimens from Peakhurst have six lobes, and two are in the unopened egg or volva stage. The specimens from Clyde Pottery, Camperdown, are especially interesting as there are six in a cluster, three of which are in the volva stage unopened, one with six bifurcate lobes, one with four bifurcate lobes and the fifth lobe with three tentacles fused together in a clathrate manner at the centre but with four quite free tips. From Penshurst there are four specimens altogether, one with six bifurcate lobes, one with six lobes—five of which are bifur-

cate whilst the sixth lobe is quadrifurcate; the other two specimens being in the volva stage. A solitary specimen from Woollahra has eight bifurcate lobes. The Dural specimen is exceptionally large, measuring five inches across from the tips of the rays, and four inches high, whilst the volva is two inches in diameter. In addition to the above localities, specimens have been recorded from Mullumbimby, Brunswick River by Kesteven (62), Richmond by Musson (106), Norfolk Island by Mueller (105) and Grant (53), and from New South Wales without specific locality by Turner (117).

The following interesting particulars, together with a coloured sketch showing eight bifid rays, with specimens from Killara collected by Mr. W. Benson, are of special interest:—

"A year or so ago I sent you a fungus which simulated a star-fish. I now send you one (or rather sketch of one) which is equally like a sea anemone, though I fear that, as before, I may be one hundred years too late to call it a novelty. It seems to be another *Aseroe.* It was found yesterday, in a drenched paddock at Killara, near another curious patch of fungi, resembling cauliflower coral. Covering a hollow, porous-looking, pink tube, about two inches high, is a thick mass of liver-coloured fungus matter which shapes itself into eight petal bases, and from each base spring a pair of tentacles, vermilion for about one quarter of an inch and then for another inch up to their tips bright orange, just like the tentacles of a sea anemone. The central mass, which may be one and a quarter inches across, having the throat of the tube in its midst, is rather tough in texture, 'nubbly' as regards surface, and very suggestive of 'protuberant proud flesh' round an abscess. Odour, putrescent. Down the tube for about half an inch, the inner surface is covered with little projecting points like miniature tubercles; these may be up to one-sixteenth of an inch long at the throat where they are largest. The section and rough sketch at foot may make my description clearer."

The specimens from Rookwood were photographed by Mr. A. G. Hamilton, who sent a copy to Mr. C. G. Lloyd, who published the following remarks concerning it (90):—

"*Aseroe Muelleriana*, the broad limbed form, cf. *Phalloids of Australasia*, p. 18. It is the first specimen of this form I have seen. Heretofore I have only known Kalchbrenner's figure."

In a subsequent memo it is again referred to by Lloyd (93) under the name *Aseroe Hookeri*, and again by the same author (85), who reproduces Mr. Hamilton's photograph, under the name *A. rubra*.

Pseudocolus rothae Lloyd (69, p. 20, fig. 21, and 70, p. 53, fig. 69). Syn. *Clathrus triscapus* Turp. in Cooke (37, No. 1191) and Bailey (10, p. 746, fig. 813); *Colus rothae* Fischer (50).

According to Lloyd (*l.c.*) there are at the Royal Herbarium, Kew (England), two collections of this species, one from Miss Carter, Moonan Brook, N.S.W., and the other from Bailey, Brisbane. Bailey sent a sketch of this specimen with the following notes:—

"Divisions of the receptacle always three, arched, and joined at the apex, of a rich orange, and obtusely triangular, porous celled. The entire portion (stipe) very short or not extending beyond the volva."

One of us (J. B. C.) collected some fine specimens at Bulli Pass, in April, 1914, which may be briefly described as follows:—Unexpanded specimens white, globose, half an inch in diameter. The receptacle from a short base at once divides into three, sometimes four, slightly arched columns which cohere at their apices, surrounding in their upper part the dark greyish-black slimy gleba. Out of eight specimens collected altogether, two had four columns and the others had three, but in one of these latter, one column was thicker and divided into two in its upper part. The

columns were about one and a quarter inches high, alveolar on their inner surface, rugosely alveolate externally, hollow, orange coloured above, becoming cream coloured towards the base. Volva fibrously rooting in the rotten trunk on which the specimens were found. Smell slightly fœtid. Spores rod-shaped with rounded ends, $3{\cdot}5 \times 1{\cdot}5\mu$.

Clathrus pusillus Berk. (13), Cheel (26, p. 839 and 28, p. 396). Syn. *Clathrella pusilla* Fischer (52, p. 284, f. 132c.)

This is a bright ruby-red coloured fungus and is popularly known as the "Ruby Lace Fungus." It was originally collected at Swan River, W.A., and recorded by Berkeley (*l.c.*) who published a figure which has been reproduced by Lloyd (69, f. 24). It has also been recorded for Wide Bay, Queensland, by Cooke (37, No. 1192) as well as for Swanbrook near Inverell, N.S.W. by Cheel (*l.c.*). From Gilgerring near York, W.A., we have received further specimens collected by Miss Bradley which were communicated by Mr. O. W. Sargent in August, 1909, and a solitary specimen was collected at Milson Island, Hawkesbury River, by J. B. Cleland and E. Cheel in July, 1912. The spores of the last mentioned specimen are colourless, elongated, $5{\cdot}3 \times 2\mu$.

Clathrus cibarius Fischer (Lace-ball Fungus).

This species was originally discovered at Waitake, New Zealand, and described by Tulasne (116) under the name *Ileodictyon cibarium*. Tulasne proposed to separate the genus *Ileodictyon* from *Clathrus* on account of the meshes of the receptacle or net-work being larger, and the branches or arms of the net having a single hollow tube, whilst those of *Clathrus* proper are cellular or pluri-tubular. The species appears to be very common in New Zealand, and has also been found in Chile and South Africa. Some fine photographs of the New Zealand plants are published by Lloyd (70, p. 60, fig. 78, and 83, p. 447, fig. 267 and 69, p. 20, fig.

22). It is very variable in size, the receptacle ranging when fully expanded from two to, rarely, more than four inches in diameter. The arms or branches of the interstices also vary very considerably, those of the typical species being usually about two-fifths of an inch (1 cm.) wide. In the National Herbarium collection, we have specimens identical with those from New Zealand, from the following localities:—

New South Wales—Arncliffe (W. Gayner, June, 1907);
Gladesville (Miss M. Flockton, June, 1907);
Mywye, Yarrangobilly (A. G. Watts, May, 1910).

Sections of the arms or branches of the Arncliffe specimens show considerable variation, both as regards their width as well as their internal structure. In some specimens the diameter of the branches is from 5 to 10 mm. The branches have also been found to contain a single tube in some cases and two or three tubes in others, even in the same specimen.

C. cibarius var. *gracilis* Fischer. Syn. *Ileodictyon gracile* Berk. (11, p. 69, t. 2, fig. 8); *Clathrus gracilis* Schlect. (113, p. 166).

This is much more common than the typical form and is even more variable, as the receptacle ranges in size from two to eight inches in diameter and the branches of the interstices are from half a line to one and a half lines thick in most specimens examined, but occasionally vary from one to two and a-half lines in the same plant.

The internal structure of the branches is for the most part tubular but occasionally it is bi-tubular. Spores of the New South Wales specimens were colourless, elongated, 4·5 to 7 × 2 to 2·5μ. This variety has a much wider distribution than the typical form, having been recorded for all the Australian States except South Australia. One of us, however, found specimens of a white *Clathrus* on several

occasions at Mount Lofty, in that State, and these were probably the form *gracilis*. We have a fine series of this variety in the National Herbarium collection as follows:—

New South Wales—Botanic Gardens, Sydney (A. Grant, May, 1900);
Centennial Park (E. Cheel, May, 1901);
Botany (L. Abrahams, September, 1901);
Mosman (A. N. Allen, June, 1913);
Manly (Miss V. Gibbons, July, 1910);
Artarmon (A. Cretin, August, 1907);
Roseville (McMillan, June, 1913);
Cheltenham (A. A. Hamilton, May, 1910);
Concord (F. O. Lovegrove, January, 1909);
Rookwood (A. Fathers, 1912);
Parramatta (I. Grainger, March, 1898);
Milson Island (J. B. Cleland and E. Cheel, 1913);
Jerilderie (J. Dykes, August, 1908);
Armidale (Miss M. Tindall);
Gostwyck, Uralla (E. T. Bateson, May, 1908);
Geeron, Forbes (— Carr, September, 1911);
Clareval, Stroud (Miss E. M. Kealy, August, 1910);
Ingleburn (A. R. Ward, 1913);
Springbank, Widgiewoi Siding (Miss M. Mackinnon, July, 1913);
Deepwater (N. S. Kellie, March, 1915);
Moss Vale (W. Challis, June, 1910).

Tasmania—Penginte (R. C. Gunn, No. 1792).

List I. Phalloideæ recorded for Australia by Cooke (37) with Lloyd's identification of each.

1175	*Dictyophora phalloidea* Desv.	= *Phallus indusiatus.*
1176	,, *tahitensis* Schlecht	= *Phallus indusiatus.*
1177	,, *speciosa* Meyen	= *Phallus indusiatus.*
1178	,, *multicolor* Berk.	= *Phallus multicolor.*
1179	,, *merulina* Berk.	= *Clautriavia merulina.*

1180 *Ithyphallus impudicus* L. = *Phallus impudicus.*
1181 ,, *quadricolor* Berk. and Br. = *Phallus multicolor* probably, which has lost its veil.
1182 ,, *calyptratus* Berk. = *Phallus* sp., not determinable.
1183 ,, *aurantiacus* M. = *Phallus rubicundus.*
1184 ,, *novæ-hollandiæ* Ca. = *Phallus rubicundus* (*P. gracilis* = *P. aurantiacus*, Lloyd).
1185 ,, *retusus* Kalchb. = *Phallus rubicundus* (*Phallus aurantiacus*, Prof. Fischer).
1186 ,, *rubicundus* Bose = *Phallus rubicundus.*
1187 *Mutinus* (?) *Watsoni* Berk. = *Nomen nudum.*
1188 ,, (?) *curtus* Berk. = *Mutinus curtus.*
1189 ,, *papuasius* Kalchb. = *Mutinus curtus* probably (J.B.C. and E.C.).
1190 ,, (?) *discolor* Kalchb. = *Phallus* (?) *discolor* (? a true species).
1191 *Clathrus triscapus* Turp. = *Pseudocolus rothæ.*
1192 ,, *pusillus* Berk. = *Clathrus pusillus.*
1193 ,, *gracilis* Schl. = *Clathrus gracilis.*
1194 ,, *albidus* Becker = *Clathrus gracilis.*
1195 ,, *cibarius* Fischer = *Clathrus cibarius.*
1196 ,, *crispus* Turp. = *Clathrus crispus.*
1197 *Colus hirudinosus* C. and S. = *Colus hirudinosus.*
1198 *Lysurus australiensis* Cke. and Mass. = *Lysurus Gardneri* (J. B. C. and E. C.)
1199 *Anthurus Muellerianus* Kalchb. = *Anthurus Archeri* (J.B.C. and E.C.)
1200 ,, *Archeri* Berk. = *Anthurus Archeri,*
1201 *Aseroe rubra* Labill. = *Aseroe rubra.*
,, ,, var. *pentactina* Endl. = *Aseroe pentactina.*
1202 ,, *lysuroides* Fischer = ? (probably wrongly figured).

List II. In addition to the species given by Cooke, the following have been recorded for Australia:—

Mutinus pentagonus (and *M pentagonus* var. *Hardyi*). Lloyd suggests that these may be young specimens of *Lysurus australiensis* (*L. Gardneri*), with which, as pointed out in our text, we agree.

Mutinus annulatus = *Jansia annulata.*

Aseroe Muelleriana = *A. rubra* (J.B.C. and E.C.)

,, *lysuroides.* Lloyd thinks that Corda's figure represents two different genera.

Clathrus albidus = *Clathrus albidus (?).*

List III. We give the following list, compiled from Lloyd's 'Phalloids of Australia,' and his other works, to replace the twenty-eight species (Nos. 1175–1202) given in Cooke's 'Handbook of Australian Fungi.' An asterisk indicates that we have specimens in our collections believed to belong to the species marked.

1. *Phallus rubicundus* (and (or) as form *gracilis**).
2. ,, *indusiatus.**
3. ,, *multicolor* (perhaps only a colour form of *P. indusiatus*).
4. ,, *callichrous* (perhaps only a colour form of *P. indusiatus*).
5. ,, (?) *discolor* (probably an incorrectly described species).
6. *Clautriavia merulina.*
7. *Mutinus curtus.**
8. *Jansia rugosa.**
9. ,, *annulata.*
10. *Lysurus Gardneri.**
11. *Anthurus Archeri.**
12. *Aseroe rubra.**
13. ,, *rubra* var. *pentactina.*
14. *Pseudocolus rothæ.**
15. *Clathrus pusillus.**
16. ,, *cibarius.**
17. ,, *cibarius* var. *gracilis.**
18. ,, *crispus* (no Australian specimens known to exist).
19. ,, *albidus* (described from Australia in a Swiss publication thirty years ago).
20. *Colus hirudinosus* (no Australian specimens known to exist).

GEASTERS.

The fungi included in the genus *Geaster* are easily distinguished from other species of the Lycoperdaceæ by the double peridia, the outer one of which splits into segments usually revolute away from the endoperidium, and finally becomes somewhat star-shaped, hence they are popularly called "earth-stars." The capillitium is mostly simple, and the spores globose and usually minutely warty or very rarely smooth.

Twenty-two species have been recorded for Australia by Cooke (37) which are distributed in the different States as follows:—Queensland 12, Western Australia 9, Victoria 8, Tasmania 5, New South Wales 5, South Australia 3 species.

Since the publication of Cooke's work, changes have been made in the nomenclature of many of the Australian fungi, and the Geasters have received special attention from Mr. C. G. Lloyd, who has had excellent opportunities for examining all the earlier collections of Australian species which are for the most part deposited in the Royal Herbarium, Kew, and the British Museum. A few collections have also been examined which are deposited in herbaria on the Continent of Europe, and as a result of this examination it has been found necessary to change the names of many of the earlier collections. In the National Herbarium there are numerous collections of these interesting plants which have been carefully preserved by one of us (E.C.) during the past fifteen years. These have been carefully compared with the excellent illustrations given by Lloyd, and together with our private collections, form the subject of the present notes.

Geaster simulans Lloyd (68, p. 17, fig. 11). Syn. *G. hygrometricus* in Cooke (37, No. 1268) but probably not of Persoon.

We have a solitary specimen of this species collected near Adelaide, South Australia, by one of us (J.B.C.) in 1898, which very closely resembles *G. hygrometricus* Pers. as already observed by Lloyd (*l.c.*). Our specimens agree very well with the figure given by Lloyd. The spores measure 4·3μ in diameter and are minutely warted. Lloyd gives the following particulars concerning this species:—

"This plant from Drummond, Australia, I found in Museum at Paris, sent by Berkeley, labelled *Geaster rufescens*. And at Kew under the same label and also the same collection (Swan River 174), labelled *G. hygrometricus*. It has no resemblance whatsoever to *G. rufescens* as now understood, but it is so close to *G. hygrometricus* that I doubt if any ordinary observer can tell them apart, judging from external appearances. The spores readily distinguish it, being in this species the ordinary size of *Geaster* spores 4 – 5 mic. *Geaster hygrometricus* can always be recognised at once by having large rough spores 10 – 12 mic. in diameter, such as no other known species of *Geaster* has."

Mueller (104, p. 119) records *G. hygrometricus* from Western Australia and Queensland, but as no mention is made of the Queensland specimens by Lloyd, and we have had no opportunity of examining specimens, we are not in a position to say whether the Queensland specimens are the same as our South Australian one, but it is quite evident that this species extends from South Australia to Western Australia.

G. floriformis Vitt. (118); Cooke (37, No. 1264); Lloyd (68, 73, p. 143); Bailey (1, p. 83).

Goulburn (E. Cheel, April, 1908); Bibbenluke (J. B. Cleland, March, 1913); Adelaide (July, 1914).

According to Lloyd (*l.c.*) there are two collections of this species at Kew, England, from New South Wales and Victoria, both correctly determined. The spores according to

Cooke (*l.c.*) are $3\frac{1}{2}-4\mu$ in diameter, brownish, globose and echinulate. The spores of our specimens are 6 to 7μ in diameter, and minutely warty. It is recorded and figured by Lloyd (67, p. 11) under the name *G. delicatus*, and the spore measurements are given as 5 to 6 mic., minutely warted.

This appears to be one of our most common species, as specimens have been collected from various parts of Victoria and New South Wales as well as New Zealand, as will be seen by the records and names of collectors given by Lloyd in his printed letters (86, 87 and 88). It is also recorded for Queensland by Cooke (*l.c.*)

G. argenteus in Cooke (37, No. 1271).

Specimens of this species have been collected at Brisbane and are at Kew, England. According to Lloyd they appear to be a large form of *G. floriformis* bleached by exposure. Cooke (37) also records it for Victoria, but these specimens are not mentioned by Lloyd.

G. Drummondi Berk. (13, p. 63); Cooke (37, No. 1253).

St. Marys (A. A. Hamilton, August, 1910); Rookwood (Miss A. Spencer, July, 1910).

This species has previously been recorded for Western Australia and Victoria by Cooke (37) and also for Victoria by Lloyd (67 and 68) who gives the spore measurements as 5 to 7μ. The spore measurements of the specimens in our collection are 5 to 6μ.

It is a rather small plant, the specimens having a beautiful dark sulcate mouth. It very closely resembles *G. striatulus* Kalchb., which also has a sulcate mouth, and is recorded for Queensland and South Australia, but so far we have not found any specimens of the latter species.

G. plicatus Berk.

This species according to Lloyd (67) is found at Madras, Banin Island, Ceylon and New Caledonia. It has also been recorded from Rookwood, N.S.W. by Lloyd (*l.c.*) and from Centennial Park, Cheel (26 and 27).

We have a fine series of additional specimens from the following localities:—Sikes Gap, Tooloom Range (J. H. Maiden, December, 1909); Badgery's Lookout, Tallong (A. G. Hamilton, September, 1911); Gladesville (Miss M. Flockton, July, 1911); Parramatta (J. B. Cleland, July, 1912). The spores of our specimens are finely warty and measure 4 to 5μ in diameter.

G. tenuipes Berk.; (Cooke, 37, No. 1250).

This species was originally recorded for Tasmania by Berkeley (16) who published a figure in the same work It has since been recorded from Byng near Canoblas by one of us (27, p. 689). Lloyd (68) has examined the specimens at Kew (England) that are from Tasmania and New South Wales, and has expressed an opinion that it is an intermediate species between *plicatus* and *pectinatus* and suggests that it should be referred to *G. pectinatus*. We have a specimen collected by one of us (J.B.C.) in April 1913, on the Hawkesbury River, the warty spores measuring 4·3 to 5μ.

G. Bryantii Berk.; Lloyd (67. p. 16).

Hawkesbury River (J. B. Cleland, July 1912).

A very large and remarkably handsome Geaster found on the Hawkesbury River under a rock seems certainly referable to this species. The lead-coloured pruinose covering of the peridium was very marked. The warty spores measured 7μ in diameter. (Plate XXV, *f.*)

G. Smithii Lloyd (67, p. 21, fig. 37 and 77). Syn. *G. striatus* Sm., Gard. Chron. 1873, p. 469, fig. 88 (Reproduced in Grevillea, Vol. 2, t. 16, fig. 1); Cooke (37, No. 1251), but probably not of DC.

We have specimens of this species in the National Herbarium from Port Lincoln, South Australia, collected by Mr. W. Gill in December, 1906, and from near Adelaide by J. B. Cleland in 1898, and also from Overland Corner, S.A. (J.B.C.) in December, 1912. Spore measurements of our specimens are 3·8 to 4·3μ. Lloyd (*l.c.*) gives the spore measurements as 4 – 5 mic. and states that the spores are rough and apiculate.

G. fornicatus Battarrea.

Hallet's Cove near Adelaide (J. B. Cleland, July, 1914).

According to Lloyd (68) a single specimen of this species is at Kew (England) collected at Brisbane and labelled *G. limbatus*. The spores of our specimen are 5μ in diameter, warty and dark brown.[1]

G. Readeri Cooke and Massee (39); Cooke (37, No. 1254, fig. 116); Lloyd (92).

N.S. Wales—Hurstville (J. H. Camfield, May, 1901); Gladesville (Miss M. Flockton, August, 1910); Dubbo (J. H. Maiden and Dr. J. B. Cleland); Gulgong (J. L. Boorman, April, 1901). South Australia—Overland Corner (J. B. Cleland, December, 1912).

The spores, in the Dubbo and Overland Corner specimens, are 3·8 to 4·3μ, warted. This species is also recorded from Victoria by Cooke (37) and Lloyd (76, p. 246, figs. 89, 90, 91).

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[1] Since this paper was read, we have received a specimen of this species from Casino, N.S.W., collected by Mr. D. J. McAuliffe.

G. minimus Schwein.

Dubbo (J. L. Boorman, August, 1908).

Previously recorded for all the States except Tasmania by Cooke (37) and for Victoria and Norwood, S.A. by Lloyd (68, fig. 21). See also Cheel (29, p. 13).

G. saccatus Fr. (44, p. 16).

This species is recorded for all the States except Victoria and South Australia by Cooke (37, No. 1261), but it has since been found to be common in Victoria (Lloyd, 68, fig. 75, *a*, *b*, *c*., and 8, 15, 17, 38). One of us (E.C., 26, p. 202) has also recorded it from Woy Woy, N.S.W. In addition to the above, we have specimens from the following localities:—Botanic Gardens, Sydney (several collectors); Mosman (A. N. Allen, April, 1912); Neutral Bay (J. B. Cleland, April, 1914); Milson Island (J. B. Cleland and E. Cheel, April, 1912); Mount Jellore (E. Cheel, April, 1912); Willoughby (E. Stack, May, 1904). The spores of several specimens examined are tuberculate, 4·2μ.

G. vittatus Kalchb. (55, p. 3); Cooke (37, No. 1260); Cheel (26, p. 202).

Cooke (*l.c.*) records this species for Australia without specifying any particular State. Lloyd (79, p. 310, fig. 145) has found it in Samoa, and considers it only a form of *G. saccatus*. The specimens recorded by Cheel (*l.c.*) were from the Botanic Gardens. In addition to the above, we have specimens from Neutral Bay (J. B. Cleland, June, 1914), Beecroft (T. Steel, June, 1915) and Bowral (Rev. W. W. Watts, May, 1909).

The spores are brown, and minutely echinulate varying from $3\frac{1}{2}$ to 5μ. Kalchbrenner (*l.c.*) gives the measurements as 0·003 mm.

G. velutinus Morgan.

Lloyd (68, p. 21) records this species from Pennant Hills near Parramatta (spelt Pawawetta) and from Gladesville. He has also recorded it for Samoa (67, p. 33). In the National Herbarium collection there are specimens from the following localities:—Waratah, near Newcastle (J. Gregson, May, 1904); Gladesville (Miss Flockton, May, 1910); Rookwood (Miss A. Spencer, June, 1910); Lilyvale (A. A. Hamilton, June, 1910); Lake Illawarra (E. Cheel, April, 1912); Coorei (A. G. Hamilton, July, 1913); Wollongbar near Lismore, (collector not given, 1912).

G. triplex Lloyd (67, p. 25 and 68, p. 23).

We have specimens of this species collected by the Rev. W. W. Watts in July 1911, from Lord Howe Island, which we have compared with a specimen of *G. triplex* kindly forwarded to one of us by C. G. Lloyd. The spores are warty and 5μ in diameter. In our specimens, the expanse of the outer peridium was two and half inches, whilst the inner peridium on its pedicel was nearly an inch high and more than three-quarters of an inch broad.

List IV.—The following is a list of the Australian species of *Geaster* recorded by Cooke (37), revised according to the investigations of Lloyd:—

1250 *Geaster tenuipes* Berk. = *G. tenuipes* as a variety of *G. pectinatus*.
1251 ,, *striatus* DC. = *G. Smithii*.
1252 ,, *striatulus* Kalchb. = *G. striatulus*.
1253 ,, *Drummondi* Berk. = *G. Drummondi*.
1254 ,, *Readeri* Cke. and Mass. = *G. Readeri* as a variety of *G. rufescens*.
1255 ,, *subiculosus* Cooke = *G. mirabilis*, of which *G. subiculosus* is a large form.
1256 ,, *lignicola* Berk. We have not found any reference to this in Lloyd's works.

1257 *Geaster minimus* Schweinf. = *G. minimus.*
1258 ,, *fimbriatus* Fr. = *G. saccatus.*
1259 ,, *australis* Berk. = *G. saccatus* (approaching the *fimbriatus* type).
1260 ,, *vittatus* Kalchb. = *G. saccatus* (as a form).
1261 ,, *saccatus* Fr. = *G. saccatus.*
1262 ,, *lageniformis* Vitt. = *G. saccatus* (as a form).
1263 ,, *Speggazinianus* Toni = *G. floriformis* (probably).
1264 ,, *floriformis* Vitt. = *G. floriformis.*
1265 ,, *pusillus* Fr. Lloyd states that no type exists and nothing is known of it.
1266 ,, *rufescens* Pers. = *G. rufescens.*
1267 ,, *lugubris* = *G. mammosus.*
1268 ,, *hygrometricus* Pers. Probably in mistake for *G. simulans.*
1269 ,, *dubius* Berk. Probably young *G. velutinus.*
1270 ,, *Archeri* Berk. = *G. Archeri.*
1271 ,, *argenteus* Cooke = *G. floriformis*, large bleached forms.

In addition to the above *Geaster oxylobata* Kalchb. is recorded for New South Wales by F. v. Mueller (104, p. 119).

List V.—The following list, chiefly compiled from Lloyd's works, is given to replace Cooke's list:—

1. *Geaster Drummondi.*
2. ,, *mammosus.*
3. ,, *striatulus.*
4. ,, *floriformis.*
5. ,, *simulans.*
6. ,, *plicatus.*
7. ,, *pectinatus* (var. *tenuipes*).
8. ,, *Bryantii.*
9. ,, *Schmidelii.*
10. ,, *Smithii.*
11. ,, *Archeri.*
12. ,, *Berkeleyi.*

13. *Geaster mirabilis.*
14. ,, *velutinus.*
15. ,, *fornicatus.*
16. ,, *minimus.*
17. ,, *rufescens* (var. *Readeri*).
18. ,, *saccatus* (and as the forms *fimbriatus*, *lageniformis*, and *vittatus*).
19. ,, *triplex.*
20. ,, *lignicola* } Recorded in Cooke.
21. ,, *pusillus* }

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Explanation of Plates.

Plate XXIV.

a. Aseroe rubra. A group of plants showing three specimens in egg-stage, two fully developed and an empty volva.

b. Lysurus Gardneri (L. australiensis). Specimen in egg-stage opened at the apex to show the seven incurved free lobes with the gleba inside, and an empty volva.

c. Lysurus Gardneri (L. australiensis). Sketch of a transverse section of receptacle, to show cellular structure.

d. Lysurus Gardneri (L. australiensis). Showing two of the lobes united at the tips.

e. Lysurus Gardneri (L. australiensis). Fully developed plant with five free lobes.

Plate XXV.

f. Geaster Bryantii.

g. Aseroe rubra. Fully developed plant with volva at base.

h. Jansia rugosa. Fully developed plant and an undeveloped plant in the egg-stage.

i. Anthurus Archeri. Fully developed plant showing two lobes united at the tips with a thin membrane.

j. Aseroe rubra. Showing upper rugose surface of the receptacle.

* * * * * *

We would like to express our indebtedness to Mr. A. G. Hamilton for the photographs of *Aseroe rubra*, Plate XXIV (*a*), and Plate XXV (*g*) and (*j*); of *Lysurus Gardneri*, Pl te XXIV (*b*) and (*e*), and of *Jansia rugosa*, Plate XXV (*h*).

DESCRIPTIONS OF NEW AUSTRALIAN BLOOD-SUCKING FLIES BELONGING TO THE FAMILY LEPTIDÆ.

By EUSTACE W. FERGUSON, M.B., Ch.M.

(From the Microbiological Laboratory, Department of Public Health.)

(Communicated by Dr. J. B. CLELAND.)

[With Plate XXVI.]

[*Read before the Royal Society of N.S. Wales, August 4, 1915.*]

THE existence of blood-sucking Leptid flies in Australia was first discovered by Dr. Cleland in June, 1911, on a branch of Middle Harbour, Sydney. Specimens taken on this occasion were forwarded to Mr. E. E. Austen of the British Museum, who found that they belonged to the Leptidæ and represented two (apparently) undescribed species. Subsequently specimens were obtained from Helensburgh, (Dr. Cox), and also from the Hawkesbury River. Unfortunately, with the exception of a few from the Hawkesbury River the laboratory collection does not now contain any of these specimens.

In 1914, Arthur White in his paper on the Diptera-Brachycera of Tasmania, described a species from Freycinet Peninsula, Tasmania, and named the genus *Spaniopsis*. His species—*S. tabaniformis* White, is however, different from any we have met in New South Wales.

In March, 1915, I obtained specimens of one species from the Hawkesbury River, on the heights surrounding the dam on the mainland from which the water supply of Milson and Rabbit Islands is derived. This proved to be the same as the specimens already in the collection from

the same locality. Further specimens of this species had been received in January from Mount Irvine, (Mr. Darnell Smith), and in March a specimen was received from Wentworth Falls, (Miss Smith). A second species was discovered on Milson Island, Hawkesbury River on April 10th. It was present in considerable numbers though not noticed on the week ends immediately preceding and following this date. On May 24th Dr. Cleland met with two further species on the Mangrove Mount Road near Gosford. A single specimen of one of these was taken by myself at Milson Island on June 3rd, while the other was met with by Dr. Cleland near Mount Wilson on June 5th. With the exception of *S. clelandi* which occurs on the mountains in summer, all the species are autumn or winter species and possibly only come out for a limited period. They are all bush flies and are found on the sandstone ridges and not in the gullies.

The discovery of a genus of Leptidæ whose members all, so far as known, possess the blood-sucking habit, is of interest, not only from the potentialities of the species for conveying disease, but also because blood-sucking flies belonging to this family are extremely rare in other parts of the world. According to Austen there are four blood-sucking species belonging to three genera. Of these, *Symphoromyia* is an American species, *Leptis scolopacea* and *L. strigosa* are found in France and appear only occasionally to suck blood, while the fourth species—*Trichopalpus obscurus*—is a Chilian species.

Only female specimens of *Spaniopsis* have so far been obtained, and the blood-sucking habit appears to be confined to this sex. Austen states that both sexes of *L. scolopacea* are said to have been observed to bite in France, though neither has been known to do so in the British Isles. When attacking for the purpose of blood-sucking,

the flies hover principally around the head, although they will settle on any portion of the body. When flying around the head they do so much in the same manner as the common bush fly *Musca vetustissima*, but it was noted, both by Dr. Cleland and myself, that when flying in front where they can be seen, the action is much more like that of a mosquito. I allowed several specimens of *S. vexans* to settle on my hands and watched the act of biting. The body of the fly was kept parallel to the surface of the hand, the proboscis being vertical, with the labellæ spread apart. The fly in no case continued long at a meal, even when undisturbed, but did not seem to have been repleted. The "bite" was felt as a sharp prick, but left no smarting nor itching afterwards, and no lump was formed as the result of the bite. If the manner of feeding of these flies is an interrupted one, as my observations on *S. vexans* seem to indicate, they may prove to be of considerable importance as mechanical transmitters of disease. Several specimens of *S. vexans* were noticed on a calf which was confined in an open pen on Milson Island. They invariably selected the moist surface of the nose and lips to settle on; after remaining motionless, apparently biting, for a short time, a fly would crawl about the surface and then settle down again. When disturbed they flew away, and the mosquito-like action was distinctly observed. Several specimens of *Stegomyia atripes* Skuse were biting at the same time and also selected the same portion of the nose and lips, and in flying, unless they are clearly seen, it was often hard to distinguish between the mosquito and the Leptid.

Very probably these flies will prove to have a wide distribution, at any rate along the coastal districts of eastern Australia, but so far they have not been met with west of the mountains. It has been suggested that these flies may have a causal connection with Bung Eye. I do not, however, think that this is likely. Bung Eye is more prevalent

in the inland parts than on the coast; it is also almost, if not entirely, confined to the summer months. *Spaniopsis* on the other hand is, so far as known, a coastal and mountain genus, and also seems to appear during the winter months. I have reason to think, however, that Bung Eye is probably more prevalent in the neighbourhood of Sydney than is generally thought. Over sixty cases occurred among the patients at Rydalmere Hospital for the Insane during three months in the beginning of the summer of 1912-13. I have also been informed that Bung Eye was exceedingly common among the men engaged in building the dam on the Hawkesbury River, on the mainland opposite Milson Island, in a locality where these flies have been taken on several occasions. Bung Eye also occurs at Mount Irvine in the Mount Wilson district, a locality whence these flies have been obtained.

The four species now to be described are all closely allied *inter se* and to *S. tabaniformis*, but can readily be distinguished by difference in size, length of arista and colouration of legs and of the ventral surface. They all exhibit the generic characters described by White in the antennæ and wing venation.

The term arista applied to the process of the third antennal joint seems to my mind somewhat misleading; it is rather a prolongation of the third joint itself. Its length varies in different species and reaches its greatest development in *S. longicornis*. In *S. vexans* and *S. marginipennis*, the discal cell varies in different specimens or on the two wings of the same specimen; in some there is a distinct angulation below, in others this is rounded off; in some the third veinlet is present as a very short stump, in others it is absent and the angulation from which it arises is rounded off. The minute veinlet inside the cell at the lower angulation described by White, was also noted in some of my

specimens. *S. clelandi* and *S. longicornis* differ from the other species in always having the third veinlet present, extending nearly or quite half way to the wing margin; the angulation below is also variable in these species.

In *S. tabaniformis*, White figures the anal cell as closed in the wing margin; in all the species before me, the anal cell is closed just before the margin to which it is united by a short stem.

In one particular all the new species differ from White's description of the genus. The tibiae are described as not having distinct spurs, although in White's description of the family Leptidæ the posterior[1] tibiae are stated to be spurred. In all the species herein described the middle tibiae possess two distinct spurs, one of them slightly larger than the other.

The following table should enable the known species to be readily differentiated.

Table of Species.

a. Legs yellow, venter yellowish.
- *b*. Wings hyaline.
  - *c*. Large species (5 mm.) = *S. tabaniformis* White.
  - *cc*. Small species (3 mm.) = *S. vexans*, n.sp.
- *bb*. Wings with anterior margin infuscate in outer half = *S. marginipennis*, n.sp.

aa. Legs bicolorus; venter dark grey
- *d*. Size medium (4 mm.), arista of moderate length (4 mm.) = *S. clelandi*, n.sp.
- *dd*. Size large (5·5 mm.), arista long (·8 mm.) = *S. longicornis* n.sp.

The types of the new species are in the collection of the Microbiological Laboratory, Department of Public Health.

[1] It is possible that "posterior" is here a misprint for "middle," as Williston places spurred middle tibiae among the characters of the family.

Cotypes have been deposited in the Australian Museum. I am indebted to Miss Phyllis F. Clarke for the drawings which accompany this paper.

SPANIOPSIS TABANIFORMIS, White.

Plate XXVI, fig. 11.

White, Royal Society of Tasmania: Papers and Proceedings, 1914, p. 44, fig. 2.

For an opportunity of examining a co-type of White's species, I am indebted to Mr. W. J. Rainbow of the Australian Museum.

The species is closely allied to the other members of the genus, and most closely to *S. vexans*. The colour of the ventral surface is not mentioned by White, but in the specimen before me, is of a greyish-yellow. This, in combination with the yellow legs, brings it close to *S. vexans*, from which it can be readily distinguished by its much larger size. The wings in this specimen appear slightly clouded along some of the veins, much as in some specimens of *S. clelandi*. This may not be constant; it is always slight in amount and seen only from certain directions. The anal cell is closed immediately before the wing margin to which it is united by a short stem. The intermediate tibiae are spurred as in the other species.

SPANIOPSIS VEXANS, n. sp.

Plate XXVI, figs. 6, 10.

♀ Resembling *S. tabaniformis* but considerably smaller. Thorax brownish with three darker longitudinal lines; abdomen dark brown with narrow paler apical bands; venter yellow; legs yellow; tarsi infuscate.

Face light grey, front dark brown. Proboscis black. Palpi yellow. Antennæ black; first and second joints short, the second joint rather shorter than the first, third joint

broadened, almost as wide as long, somewhat concave on its inner surface, produced into a short stout arista, not quite as long as the rest of the antenna. Thorax yellowish-brown, sides and anterior margin with a greyish bloom, with three darker longitudinal lines, not quite reaching base, the median line slightly narrower and not extending quite as far as the others. Abdomen dark brown, the basal segment lighter, each segment with a narrow light yellowish-brown apical border, the apical segment almost entirely of this colour. Ventral surface yellow. Legs pale yellow, tarsi with first joint infuscate at apex, the other joints dark, intermediate tibiae with two apical spurs. Wings with venation characteristic of genus, the third veinlet very short or absent, the angulation below variable; hyaline, veins and stigma dark brown. Length 3 mm.; antennæ ·55 mm., third joint ·17 × ·14 mm., arista ·26 mm.

Hab. New South Wales, Milson Island (Hawkesbury R.)

This species was taken on two successive days, April 10th and 11th, and was not noticed a week previous or a week after this date. It is the smallest species known, and can readily be distinguished by the combination of small size, yellow legs and yellow venter. The species was fairly abundant when taken and was noticed to be attacking cattle on the island. About thirty specimens were taken, but unfortunately almost all turned black after being pinned.

SPANIOPSIS MARGINIPENNIS, n. sp.

Plate XXVI, figs. 2, 4, 8.

♀ Similar to *S. tabaniformis*, but with wings infuscate along outer portion of anterior margin. Thorax brownish with three darker longitudinal lines; abdomen dark, with paler apical bands; venter yellow; legs yellow, tarsi infuscate.

Face light grey, front dark brown. Proboscis black. Palpi yellow. Antennæ black; first and second joints small, third joint broadened, longer than wide, terminating in a long thick arista, not quite twice as long as rest of antenna. Prothorax brown, with a somewhat yellowish tint, sides and apex with a greyish bloom; with three darker longitudinal lines, not quite reaching base, the median the narrower. Scutellum brown. Abdominal segments dark brown, bordered apically with a moderately broad greyish-yellow band interrupted in the middle, apical segment greyish-yellow with a median dark spot. Venter light greyish-yellow, sides similarly coloured. Legs pale yellow, tarsi with first joint infuscate at apex, the other joints dark; intermediate tibiae with two apical spurs. Wings with characteristic venation, the third veinlet very short or absent, the angulation below variable; deeply infuscate along anterior margin from inner end of stigma to apex of wing; stigma dark brown or black, veins dark brown, yellowish at base. Length 4·5 mm., antennæ ·97 mm. third joint ·22 × ·15 mm.; arista ·6 mm.

Hab. New South Wales, Gosford, (J. B. Cleland, 24/5/15), Milson Island (E. W. Ferguson, 3/6/15).

This species may be readily identified by the dark anterior margin of the wings. The dark portion is moderately broad and fades away below, but its lower border is fairly sharply defined. The arista is considerably longer than in *S. vexans*, to which it is most nearly related in its yellow venter and legs. The specimens were taken by Dr. Cleland in company with *S. longicornis* on the Mangrove Mountain Road behind Gosford, and were captured while trying to bite.

SPANIOPSIS CLELANDI, n. sp.

Plate XXVI, fig. 5, 9.

♀ Of medium size. Thorax brown with three darker longitudinal lines; abdomen dark brown with lighter apical bands; venter darker grey; legs bicolorous.

Face grey; front dark brown. Proboscis black. Palpi dark brown. Antennæ black; basal joints short, third joint broadened, arista about as long as rest of antenna, the whole antenna about the same length as the arista in *S. longicornis*. Thorax dark brown with a greyish bloom at apex and on sides, with three darker longitudinal lines, the median not reaching base. Scutellum brown. Abdominal segments dark brown with moderately broad, greyish apical bands, somewhat undulate but not interrupted in the middle, basal segment almost entirely greyish, the two apical segments greyish with a median basal dark spot. Venter and sides dark grey. Legs bicolorous; tibiae light yellowish-brown, apex darker; tarsi with first segment yellowish-brown, darker at apex, other joints dark. Wings with characteristic venation; third veinlet constantly present, moderately long, reaching about one-third of the way to the costal margin; anal cell closed immediately before margin; hyaline, veins and stigma dark, a very faint infuscation traceable along the course of the veins in some specimens. Length 4 mm.; antennæ ·87 mm.; third joint ·26 × ·19 mm.; arista ·43 mm.

Hab. New South Wales, Hawkesbury River (March), Mount Irvine (January), Wentworth Falls (March).

Allied to *S. longicornis*, but with shorter antennæ and shorter arista; the third joint is also differently shaped. This species may be separated from the other members of the genus by the colour of the legs.

Several specimens without locality label and in a bad condition are in the collection—some of these may be from Middle Harbour or Helensburgh, but I think they are all Hawkesbury River specimens. The Blue Mountain specimens are also in bad condition, having turned black, but I have no doubt they are referable to this species. The slight infuscation along the veins is very faint and difficult

to trace—it seems absent in some specimens. One specimen without locality, in the collection, has the veins much lighter, almost yellowish in colour; it is possibly distinct, but is an old specimen and may have faded; unfortunately both antennæ are broken.

I have much pleasure in naming this species after Dr. J. B. Cleland who was the first to discover these flies.

SPANIOPSIS LONGICORNIS, n. sp.

Plate XXVI, figs. 1, 3, 7.

♀ Size comparatively large for the genus; most nearly allied to S. *clelandi*. Antennæ with long thick terminal arista; thorax dark greyish-brown with three longitudinal darker lines, and an interrupted dark line at sides; abdomen dark brown with paler apical bands to segments; venter darker grey; legs bicolorous; wings hyaline.

Face light grey; front dark brown. Proboscis black. Palpi yellow. Antennæ black, very long, basal joints short, third joint twice as long as wide, terminating in a long thickened arista, not quite twice as long as the rest of the antenna. Thorax greyish-brown with three darker longitudinal lines, the median narrower than the others, the two submedian apparently connected at the base, also with an interrupted dark line near side, connected across with submedian line at apex and at level of transverse suture. Scutellum brown. Abdomen dark brown with a broad greyish band at apex of segments, interrupted in middle, basal and apical segments greyish. Venter and sides dark grey. Legs bicolorous; femora brown, the anterior pair almost black, with the base and apex of a lighter more yellowish colour; tibiae yellowish, slightly darkened at apex; tarsi with basal joints yellowish, infuscate at apex, the other joints dark. Wings hyaline, veins black, stigma brownish; venation as in genus, third veinlet always present, longer than in S. *tabaniformis*, reaching almost

or quite half way to wing margin; anal cell closed immediately before wing margin. Length 5·5 mm.; antennæ 1·35 mm., third joint ·32 × ·16 mm., arista ·87 mm.

Hab. New South Wales, Gosford, Mount Wilson (Dr. J. B. Cleland).

Specimens were taken by Dr. Cleland on May 24th, 1914, in company with *S. marginipennis* on the Mangrove Mountain road near Gosford. Additional specimens were also procured on the Mount Wilson-Mount Irvine road about two miles from the former place (6/6/1915). Both Mount Wilson and Mount Irvine have basaltic caps with corresponding brush formation—the specimens were however taken on the sandstone formation which outcrops on the road, and none were seen in the bush.

It is probably this species or *S. marginipennis* or possibly both, to which Mr. Gallard of the Agriculture Department alluded in a communication to Dr. Cleland in 1911. Mr. Gallard met with them at Ourimbah (Gosford district) in June, and says:—"They frequent the scrubby land where the wallabies are generally found, and we call them wallaby flies. If you bare any part of you, they attack you like a mosquito, and their bite is far worse." *S. longicornis* is closely related to *S. clelandi*, but the larger size and longer antenna should prevent the two species being confused.

Explanation of Plate XXVI.

1. *Spaniopsis longicornis*, n. sp. ♀
2. ,, *marginipennis*, n. sp. ♀
3. ,, *longicornis*, n. sp. Wing.
4. ,, *marginipennis*, n.sp. Wing.
5. ,, *clelandi*, n. sp. Wing.
6. ,, *vexans*, n. sp. Wing.
7. ,, *longicornis*, n. sp. Antenna.
8. ,, *marginipennis*, n. sp. Antenna.
9. ,, *clelandi*, n. sp. Antenna.
10. ,, *vexans*, n. sp. Antenna.
11. ,, *tabaniformis* White. Antenna.

THE AGE OF THE SOUTHERN COAL FIELD TABLELAND BASALTS.

By L. F. HARPER, F.G.S.,
Geological Surveyor, Department of Mines.

[*Read before the Royal Society of N. S. Wales, September 1, 1915.*]

As far as the writer is aware it has been generally taken for granted that the basalt occurrences found on the Robertson and Sassafras tablelands are of Tertiary age. It is intended in this paper to bring forward evidence which it is thought points strongly to their having resulted from a later period of volcanic activity. The grounds for this opinion may be summarised as follows:—

1. Palæontological evidence, in the form of plant remains obtained from the sediments under the basalts, points to as great an affinity to Pleistocene as to Pliocene forms.

Consequently these beds may be assigned to a period of deposition not older than late Pliocene.

2. The uplift which resulted in the formation of the tableland areas took place in Pleistocene time.

3. The uplift gave rise to the faulting found in the northern portion of the Southern Coal Field.

4. *Subsequent* to the faulting, volcanic intrusions took place and the resultant igneous rocks bear a most striking chemical and petrographical affinity to the tableland basalts.

5. The physiographic disposition of the tableland basalts points to their having in many instances welled over areas of country with drainage channels almost identical with those of the present day, showing but little discrepancy as to stages of maturity in land surfaces.

The evidence in support of the foregoing is as follows:—

1. *Palæontological.*

In the Wingello District, beds underlying the areas of basalt contain fossil plant impressions which have been identified and described by Mr. H. Deane. The forms are considered by Mr. W. S. Dun to belong to a late Tertiary or possibly Post Tertiary period, so that palæontological evidence points to the sedimentary rocks immediately underlying the basalt representing, at the very oldest, a period of late Tertiary deposition.

2. *Age of the uplift.*

These late Tertiary deposits are found at an average altitude of over 2,000 feet above sea level, but their comparatively low altitude at the time of deposition is indicated by the absence of any evidence as to contemporaneous precipitous river valleys, and the fine grained nature of most of the sediment. Hence we may assume that the uplift took place during transition to the Post Tertiary period.

3. *Faulting follows uplift.*

The uplift is confined to the central portion of the area under review, and north from a line projected through Kiama and Robertson, the land surface not only sagged behind, but also merged into an area of subsidence. Similar conditions pertain at the southern end of the uplifted area, and the movement gradually dies away south from Termeil.

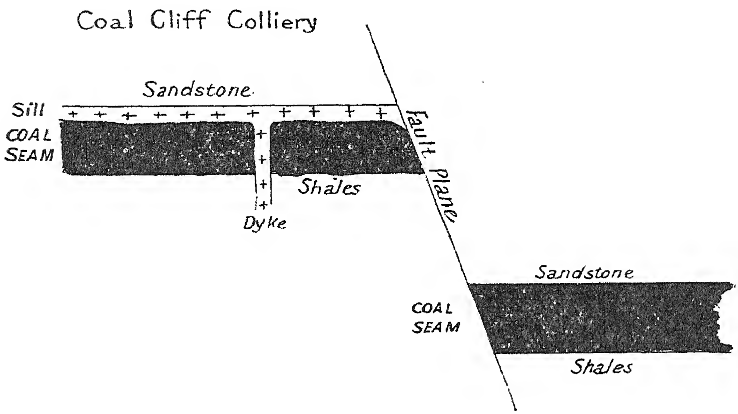
The faulting found in the Southern Coal Field is confined to the areas which sagged behind during the uplift, and consequently underwent severe straining and fracturing.

It is in these areas that evidence of volcanic activity is most pronounced.

4. *Faulting preceded volcanic intrusions.*

There is abundant evidence that the faulting preceded the volcanic intrusion, but only two instances need be cited.

In the colliery workings at Coal Cliff the following instances were noted.



(*a*) A dyke ten inches wide intersects the Bulli coal seam vertically, and on reaching the roof spreads out horizontally as a sill, eight inches thick, having failed to pass into the sandstone roof.

About eight feet from the dyke, a fault with a downthrow of eleven feet has thrown the sandstone roof opposite the coal seam, thus preventing the sill from extending beyond the coal. On the downthrow side of the fault the coal is unaltered, and no sill rock is present.

(*b*) In another portion of the same colliery, a dyke five inches wide is seen occupying a fault plane, the amount of displacement caused by the fault being twenty-one feet.

(*c*) In the Metropolitan Colliery, a fault with a displacement of over two hundred feet has been proved, which resulted in No. 4 coal seam being thrown opposite No. 1.

No. 1 seam consists of about twelve feet of coal absolutely unaffected by volcanic agencies, whereas No. 4 is almost totally destroyed by a sill up to seven feet in thickness, and which has been driven on for approximately half a mile.

The sill ends up abruptly at the fault, and the volcanic material has been forced along the plane for a few feet. Minor faulting leading to displacement of under two feet followed, and finally further volcanic activity led to the sill being intersected by several dykes.

The geological phenomena which have been mentioned appear to have occurred in the following order:—

1. Deposition of fossiliferous sediments, late Tertiary age.
2. Uplift, Transition period.
3. Faulting, Post Tertiary age.
4. Intrusion of sills and dykes, Post Tertiary age.
5. Further slight faulting, Post Tertiary age.
6. Intrusion of later dykes, Post Tertiary age.

The tectonic forces indicated must have occupied a considerable time, for the uplift was gradual, otherwise very heavy faulting would have taken place. Such is not the case, however, for the maximum amount of displacement by any individual fault is only about 230 feet, as agaiust an uplift of 2,000 feet.

It is recognised that no great lapse of time was necessary for the four latter phenomena to have taken place, but it was by no means abrupt. The very fact of the uplift indicates a change of epoch, and it is thought that the evidence points to the dykes and sills having been injected during a Pleistocene epoch.

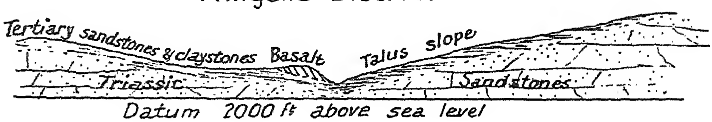
Chemical and petrographical work indicate a marked affinity between the dykes and sills and the basalts found capping the tableland areas, and a common magma basin and period of vulcanicity is evidenced.

No vents were found from which the surface basalts could have emanated, and it is thought that they represent a portion of the volcanic product which welled over the earth's surface from fissures induced by the uplift.

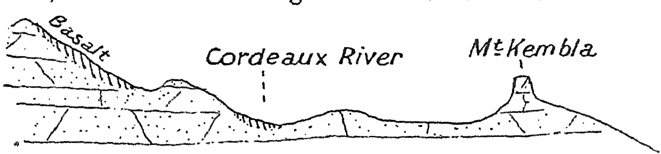
A further point in favour of a Post Tertiary age being assigned to the tableland basalts is their physiographic disposition. In many instances they are found to have accumulated over areas of country with drainage channels corresponding in a marked degree with those of the present day, thus indicating practically no topographic changes.

Two instances of this feature may be cited. The following section, published in the Iron Ore Deposits of New South Wales, by Mr. J. B. Jaquet, Chief Inspector of Mines, indicates the amount of erosion which had taken place in the late Tertiary beds prior to the outpouring of the basalt. It also shows how closely Post Tertiary drainage channels agree with those of the present day.

Wingello District



The second instance occurs in the valley of the Cordeaux River, where the following section was obtained.



It will be noticed from this section how the basalt sheet occupies slopes identical with those of the present day land surface, and how an outlier of the Triassic rocks forms an "island" now as it did at the time the basalt was outpoured.

A NOTE ON THE RELATION BETWEEN THE THERMAL CONDUCTIVITY AND THE VISCOSITY OF GASES WITH REFERENCE TO MOLECULAR COMPLEXITY.

By J. A. POLLOCK, D.Sc.,
Professor of Physics in the University of Sydney.

[*Read before the Royal Society of N. S. Wales, October 6, 1915.*]

IN the equation $k = f\eta c_v$, expressing the thermal conductivity of a gas in terms of the viscosity and specific heat, the coefficient f is a numerical factor which is approximately constant for gases of the same atomicity. Such a fact suggests the probability of a relationship between f and γ, the ratio of the specific heats. But long before the result, just mentioned, was fully established, the probability of f being a function of γ was recognised, though it was not generally appreciated. As early as 1876 Boltzmann,[1] from theoretical considerations, obtained the expression $f = 3f'(\gamma-1)/2$, where f' is the constant for monatomic gases. It has been known for some time that the equation is physically inaccurate, but the matter does not seem to have been followed further.

Recently new results for the thermal conductivities of a number of gases have been published by Eucken.[2] In connection with these measures, Eucken discusses the dependence of f, not only on the properties of the molecule, but also on the temperature. As possibly lying outside the main lines of his investigation, he does not consider the relationship of f to γ, but, from the zero temperature

[1] Boltzmann, Pogg. Ann., 157, p. 457, 1876; see also Schleiermacher, Wied. Ann., 36, p. 346, 1889, and Chapman, Trans. Roy. Soc., 211, A, p. 433, 1912.

[2] Eucken, Phys. Zeitschr., 14, p. 324, 1913.

values of the thermal conductivities and viscosities given by him, a relation appears to exist between the two factors which can be expressed by an equation of the form

$$f = \frac{a\,(\gamma-1)}{\gamma^n},$$

where a and n are constants. The precise arithmetical adjustment of these constants may well await further measures; in the meantime, with numerical simplicity as well as physical accuracy in view, the equation may be written

$$f = \frac{7{\cdot}32\,(\gamma-1)}{\gamma^{1{\cdot}3}}.$$

If, in the original expression, n, the power of γ, is put equal to unity, the equation, with an appropriate value of the constant, quite well represents the experimental results with the exception of those for the monatomic gases. This leads, in the case of perfect gases, to the simple relation

$$\frac{m\gamma k_\circ}{\eta_\circ} = \text{constant},$$

where m is the molecular mass.

In the following table, with the zero temperature measures of k and η, taken from Eucken's paper, I give, for the calculation of f, the experimental results for c_p and γ instead of the values of c_v. The figures given for f in column 2 of Table II, deduced from the equation $k = f\eta c_p/\gamma$, are thus wholly dependent on the results of experiment.

TABLE I.

1	2	3	4	5	6
Molecule.	m	$k_\circ \times 10^6$	$\eta_\circ \times 10^6$	c_p	γ
He	4	336	187·6	1·260*	1·63
A	40	39·0	210·2	0·123	1·667
H_2	2	397	85	3·422†	1·402†
N_2	28	56·6	167·6	0·2429†	1·412†
O_2	32	57·0	192·2	0·2173†	1·402†
Air	29	56·6	171	0·2376†	1·405†
Cl_2	71	18·29	123·7	0·115	1·323‡
CO	28	54·25	167·2	0·2502*	1·401
NO	30	55·5	179·4	0·232	1·394

TABLE I—*continued.*

1	2	3	4	5	6
Molecule.	m	$k_0 \times 10^6$	$\eta_0 \times 10^6$	c_p	γ
H_2S	34	30·45	118·4	0·245	1·340
CO_2	44	33·7	138	0·2010	1·300
N_2O	44	35·15	136·2	0·213	1·324
SO_2	64	19·5	118·3	0·1544‡	1·256
CS_2	76	16·15	92·4	0·160	1·239
NH_3	17	51·35	92·6	0·520	1·336
C_2H_2	26	44·0	94·3	...	1·26
CH_4	16	71·45	102·9	0·591	1·313
C_2H_4	28	40·7	90·66	0·404	1·264
C_2H_6	30	42·6	85·5	...	1·22

* Scheel and Heuse, Ann. d. Physik, 40, 3, p. 473, 1913. † Escher, Ann. d. Physik, 42, 4, p. 761, 1913. ‡ Landolt-Börnstein Tabellen. All other values in columns 5 and 6, from Kaye and Laby's Tables.

TABLE II.

1	2	3	4
Molecule.	f obs. $\frac{\gamma k_0}{\eta_0 c_p}$	f cal. $\frac{7 \cdot 32\,(\gamma - 1)}{\gamma^{1 \cdot 3}}$	$\frac{m\gamma k_0}{\eta_0}$
He	2·32	2·45	11·6
A	2·51	2·51	12·4
H_2	1·91	1·90	13·2
N_2	1·96	1·93	13·4
O_2	1·91	1·90	13·3
Air	1·96	1·91	13·5
Cl_2	1·70	1·63	13·8
CO	1·82	1·89	12·7
NO	1·90	1·87	12·9
H_2S	1·41	1·70	11·7
CO_2	1·58	1·56	14·0
N_2O	1·60	1·65	15·0
SO_2	1·35	1·39	13·3
CS_2	1·35	1·32	16·5
NH_3	1·79	1·69	12·6
C_2H_2	...	...	15·3
CH_4	1·52	1·61	14·6
C_2H_4	1·40	1·43	15·9
C_2H_6	...	...	18·3

In this second table, the values of f, derived from the expression $f = 7{\cdot}32\,(\gamma - 1)/\gamma^{1{\cdot}3}$, are entered in column 3. An idea of the physical accuracy of the calculated results may, therefore, be obtained from a comparison of these figures with those in column 2. There are certainly large differences between the calculated and observed values for some gases, but the experimental determinations cannot be considered in all cases as final.

The last column of Table II contains the values of $m\gamma_\circ k_\circ/\eta_\circ$. As prevously mentioned, with the present experimental results, constancy of the value of the ratio is only to be expected in the case of perfect gases with molecules of an atomicity greater than 2. The approximate similarity of the figures in some number of instances is, therefore, perhaps more remarkable than the divergencies in the other cases.

It is interesting to note the rise that has taken place in the values of the thermal conductivities. For many years the determinations of f for diatomic gases were cited in support of Meyer's well known theoretical deduction, $f = 1{\cdot}6027$. Now, from Eucken's measures of the thermal conductivities, the value of f for these gases is $1{\cdot}9$.

THE WAVE-LENGTH OF THE ELECTRICAL VIBRATION ASSOCIATED WITH A THIN STRAIGHT TERMINATED CONDUCTOR.

By J. A. POLLOCK, D.Sc.,
Professor of Physics in the University of Sydney.

[*Read before the Royal Society of N. S. Wales, October 6, 1915.*]

To a first approximation, Abraham[1] and other writers conclude from theoretical considerations that the wave-length of the disturbance in free ether due to the gravest electrical vibration on a thin straight terminated conductor is equal to twice the length of the rod. This result is very definitely supported by Lord Rayleigh[2] in opposition to the calculation of Macdonald[3] which makes the wave-length 2·53 times the length of the conductor.

Some years ago I published an account[4] of an experimental comparison, by a resonance method, of the periods of the electrical vibrations associated with simple circuits. In discussing the results, I assumed that the wave-length of the oscillation connected with a narrow rectangular circuit was equal to the perimeter of the rectangle, and was led to think that the measurements supported Macdonald's theoretical deduction as to the wave-length of the vibration on a straight rod. The assumption, which affects the discussion only, is, however, quite unjustifiable, as the wave-length depends on the ratio of length to breadth as well as on the perimeter of the circuit. Contrary to the opinion I then expressed, the experimental results cannot be taken as supporting Macdonald's theory.

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1 Abraham, Ann. der Physik, 66, p. 435, 1898.
2 Rayleigh, Phil. Mag., 8, p. 105, 1904; Phil. Mag., 25, p. 1, 1913.
3 Macdonald, Electric Waves, p. 111, 1902.
4 Pollock, Jour. and Proc. Roy. Soc. N.S. Wales, 37, p. 198, 1903; Phil. Mag., 7, p. 635, 1904.

More recently several values of the ratio of wave-length to length of conductor, determined from interference experiments, have been given in accounts of measurements of electric waves from linear oscillators of small dimensions. Writing $\lambda = kl$, where l is the length of the conductor, Willard and Woodman[1] deduce for k the value 2·48; Cole,[2] 2·52; Blake and Fountain,[3] 2·47, and Webb and Woodman,[4] 2·3. Finally Ives,[5] using a very high resistance receiver with an interferometer arrangement, finds 2·04 as the value of k for certain linear oscillators varying in length from 5 to 10 centimetres.

At the meeting of the British Association in Sydney, in 1914, I mentioned that the interference experiments had recently been repeated by students in the Physical Laboratory of the University, with results completely confirming those of Ives. I now give a summary of the measurements.

In the interferometer experiments Ives' general arrangement has been followed, but a coherer was used as a receiver instead of one involving a thermo-electric junction. At each observation the coherer was isolated during the passage of the waves, being connected to the galvanometer circuit, by moveable conductors working in mercury cups, only after sparking had ceased. A coherer used in this way is unaffected by disturbances not in its immediate neighbourhood.

The positions of the nodes of the stationary wave system, formed by the reflection of an incident beam at a plane zinc mirror, have also been determined with the same coherer arrangement. The results exactly agree with those found with the interferometer.

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[1] Willard and Woodman, Phys. Rev., 18, p. 1, 1904.
[2] Cole, Phys. Rev., 20, p. 268, 1905.
[3] Blake and Fountain, Phys. Rev., 23, p. 256, 1906.
[4] Webb and Woodman, Phys. Rev., 29, p. 89, 1909.
[5] Ives, Phys. Rev., 30, p. 199, 1910; 31, p. 185, 1910.

For these and the interferometer measurements, the oscillator, sparking in paraffin, was placed at the focus of a cylindrical parabolic mirror, the focal length being an odd multiple of a quarter of the wave-length to be expected. Experiments have been made with mirrors whose focal lengths were calculated from the lengths of the oscillators on the basis of both Abraham's and Macdonald's theories. Ives' conclusion that the focal length of the oscillator mirror has a negligible effect on the wave-length has been verified.

The various values which have been found are set out in the following table, together with the names of the experimenters who carried out the considerable practical work involved in the determinations. To make the evidence complete, I have included the results of Ives' measurements. The other measures, previously mentioned, are not given in the table as the earlier experiments are open to the criticism that the influence of the receivers was not entirely eliminated. Ives' use of a very high resistance in the receiver circuit quite obviates an error of this kind. In the experiments in this laboratory, coherers of very dis-

Experimenters.	Length of Oscillator	λ observed.	λ calculated	k observ'd	k calcul'd.	Experimental Method.	Number of nodes determined.	Approximate distance from plane mirror.
*Ives	4·93	10·42	10·12	2·11	2·05	Interferometer.		
	7·49	15·24	15·30	2·03	2·04	,,		
	9·85	19·86	20·06	2·02	2·04	,,		
†Booth & Tiddy	5·06	10·40	10·30	2·06	2·06	,,	3	
,,	,,	10·54	,,	2·08	,,	Stationary Waves.	4	100λ.
,,	,,	10·46	,,	2·07	,,	,,	4	,,
,,	,,	10·40	,,	2·06	,,	,,	3	5λ.
,,	18·84	38·47	38·38	2·05	2·03	,,	11	20λ.
‡Anderson and Scarr	,,	38·00	,,	2·01	,,	,,	5	5λ.

* Ives, *loc. cit.*. † E. H. Booth, H. P. Tiddy. ‡ R. C. Anderson, J. H. A. Scarr

similar dimensions were employed in verifying the results, and it was definitely proved that the measurements were wholly independent of any characteristic of the receiving circuits.

In his theoretical discussion of this subject Abraham[1] considers the vibration about a perfect conductor in the form of an elongated ellipsoid of revolution. When the minor axis ($2b$) becomes negligibly small in comparison with the major axis (l), the wave-length in free ether of the disturbance due to the fundamental vibration is equal to $2l$. In a second approximation Abraham obtains the following expression for this wave-length:—

$$\lambda = 2l\,(1 + 5{\cdot}6\epsilon^2)$$

where $1/\epsilon = 4 \log_e l/b$.

In the table, under the heading 'λ calculated,' are given the wave-lengths deduced from this equation, and under 'k calculated,' the ratio of these wave-lengths to the lengths of the oscillators.

A consideration of the evidence shows that Abraham's expression gives a result for the wave-length which agrees with the measured value within the present limits of experimental error. This was Ives' conclusion in 1910, and the results now published add to his statement but the weight attached to confirmation from independent work. The physical accuracy of Abraham's deduction is now sufficiently well established for linear oscillators of known dimensions to be used as standards in connection with the measurement of short electric waves.

These results completely support Lord Rayleigh's[2] view of the value of the wave-length of the vibration on a thin straight terminated rod, and at least imply the experimental verification of his contention "that the difference

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[1] Abraham, *loc. cit.* [2] Rayleigh, *loc. cit.*

between the half wave-length of the gravest vibration and the length (l) of the rod (of uniform section) tends to vanish relatively when the section is reduced without limit."

The experiments lend no support to Macdonald's calculation which requires that the numbers in the table under the heading 'k observed' should be 2·5. It would appear, then, that Sarasin and De la Rive's well known experiments which, hitherto, have only been quantitatively described in terms of Macdonald's theory, still await their explanation.

THE AUSTRALIAN "GREY MANGROVE," (*Avicennia officinalis*, Linn.)

By R. T. Baker, F.L.S.,
Curator, Technological Museum, Sydney.

With Plates XXVII - XLVI.

[*Read before the Royal Society of N. S. Wales, November 3, 1915.*]

1. Introduction.
2. Description of Species.
3. Synonymy.
4. Systematic position of this Australian Mangrove.
5. The Leaves.
6. The Breathing Roots.
7. The Seed.
8. Timber:—(*a*) Economics.
   (*b*) Analysis of the Ash.
   (*c*) Macroscopical Characters.
   (*d*) Histology.
   (*e*) Fibres.
9. Bark.
10. Concentric "Rings," and their relation to the age of the tree.
11. Illustrations.

1. Introduction.

Several species of plants are commonly known under the name of "Mangrove,"—belonging, however, to different Natural Orders, the term being given by the layman to those trees found growing in muddy, saline, foreshores. Botanically, it is generally restricted to those species assigned to the Natural Order RHIZOPHOREÆ, but the reason for such restriction is not clear. Indeed, I am in favour of its being applied only to those trees which have one common characteristic, *i.e.*, the curious property of having breathing roots or pneumatophores, such as *Avicennia*, *Laguncularia*, *Sonneratia*, etc. As it is probably impossible now to alter the common application of the term, the name "Grey Mangrove" is associated in this paper with the genus *Avicennia*, N.O. VERBENACEÆ, the species being *A. officinalis*, Linn., and as this is one of Linnæus' species, its systematic position dates back a long way in botanical works.

I would like to take this opportunity of acknowledging my great indebtedness to Mr. T. C. Roughley, of the Scientific Staff of the Technological Museum, for the photographs and sections illustrating this paper; to Mr. J. H. Maiden, and Prof. A. J. Ewart for the loan of literature bearing on the subject, and also to Mr. T. Dick for specimens and local information.

2. Description of the Species.

The plant upon which the research is made may be described as a species attaining full tree size, with a pale coloured comparatively smooth, very thin exterior bark, not much more than one-sixteenth of an inch in thickness on the tallest trees. Branchlets angular, leaves opposite, ovate to occasionally lanceolate, mostly acute, petiole about half an inch long, margins slightly recurved, length about three inches and under, breadth varying up to one

and a half inches, shining on the upper side, clothed with a short tomentum on the lower. Cymes in capitate heads on fairly long peduncles in the upper axils; bracts and bracteoles small, hirsute with brown hairs, same as calyx, which is five partite, segments ovate, imbricate, the two within smaller than the other three. Corolla tube turbinate (top shaped), lower half glabrous outside, lobes concave, hirsute, anthers not exserted. Pistil short, bifurcated, hidden except the stigma in the straight erect hairs at the top of the ovary, which is glabrous and shining below this tuft of hairs. Ovary imperfectly four celled with four pendulous ovules. Capsule flattened, yellowish, dehiscing by two thick valves, one seeded. Seed erect, hypocotyl villous, but the hairs have not barbed tips.

In this connection it may not be out of place perhaps to mention that Robert Brown in Prod. Fl. Nov. Holl., 1882-5, p. 374, states:—"Embryonis radicula barbata." A feature recently claimed to have been discovered by Karsten, are the anchoring hairs of the hypocotyl of *Avicennia officinalis*, but no traces of such could be found on the specimen examined by me.

3. Synonymy.

It was not until trying to specifically place the botanical material for this research that the confusion surrounding this species of the genus became apparent. The Index Kewensis gives fourteen species in all, and of these twelve are synonymised under *A. officinalis*, the other *A. nitida*, standing as the only other valid species. When the genus is monographed I should not be surprised if the greater number of these were found to be good species.

To me, it seems scarcely possible that one species, *A. officinalis* should have such an extensive range as the synonyms *(ante)* would indicate.

The descriptions of the species are scattered through much botanical literature, and consequently great difficulty was experienced in trying to trace Linnæus' description of *A. officinalis*, and even now I am not sure of my ground, as all the descriptions of this tree, within the last fifty years are no doubt composite ones, and include several good species. As far as I have been able to penetrate the subject, I consider at least *A. tomentosa* and *A. alba* as distinct from what I regard as *A. officinalis*. The nearest description of the species of this paper is that published in Kirk's "New Zealand Flora," p. 271. Forster originally named this *A. resinifera*, but it has since been shown he was in error in ascribing a resinous exudation to his New Zealand Mangrove. The resin found in the mud amongst the New Zealand Mangrove was the Kauri resin now well known, and did not come from this mangrove. The New Zealand Mangrove appears to be identical in some respects with the Australian, and further evidence may show a close connection with the Indian and American species.

As far as I have been able to ascertain, no plate of Linnæus' *A. officinalis* is extant, and most of the illustrations going under the name are either *A. tomentosa* or *A. alba*, or another synonymised species, but in order to more definitely systematically place the species, a full description is given above, in which will be found differences from those descriptions and figures in Wight's Ic. t. 1481, under the name of *A. alba* and *A. tomentosa*, now synonymised as *A. officinalis*. The leaves also figured (*loc. cit.*) differ from those of this species.

4. Systematic Position of this Australian Mangrove.

Most of the descriptions of *A. officinalis* give the leaves as "obovate, cuneate, obtuse" which does not apply to this species, nor can it be *A. tomentosa*, figured by Wight Ic.

Pl. Ind., 1481-2, which has quite a different shaped leaf, stamens, ovary and pistil from those of the Australian plant. It more nearly approaches in its organs the figures of *A. alba*, which is recorded as a small tree or shrub as against the large sized tree of the Australian *Avicennia*.

Linnæus, himself, later reduced his *A. officinalis* under *A. tomentosa* a name now restricted to the American tree, an action which seems rather to have confused matters, and in opposition to this I propose to restore Linnæus' original name until a correct description is available, as well as an original specimen for comparison.

In order that the species may be more definitely placed in future, features other than morphological have been investigated, especially the microscopical structure of its several parts or organs, such as leaves, pneumatophores, timber, bark, and germination of the seed.

5. Leaves.

These trees as a rule have a most luxuriant growth of leaves, and this is what might be expected in view of the fact that the ash of the wood contains a high percentage of potassium salts *(infra)*.

(a) *Histology*.—A transverse section, (Plate XXVII, figure 1) shows the structure of this organ to be quite unique. Except for one row of epidermal cells the upper half is composed entirely of a delicately walled material of irregularly shaped cells, evidently for water-storing—the "water tissue" as now understood, the larger cells being towards the middle of the leaf. This structure is succeeded in the lower half from the central axis of the blade by three, sometimes four rows of palisade parenchyma, which occupy the slightly larger part of this half of the leaf, and is followed by thin-walled loose parenchyma cells, or spongy mesophyll. Throughout the structure are scattered trachea

vessels of the ordinary type. In the younger leaf the central bundle or mid-rib is surrounded by a band of protoxylem which in the more mature leaf becomes wood fibres. This is backed by loose parenchyma, probably water storing cells (Plate XXVIII, figure 2).

The tomentum, microscopically examined, is seen to consist of cup-shaped, peltate, closely packed hairs, which in outline rather resemble a shallow vase or tazza, or even some forms of fungus, like *Stereum*, with mostly a two-celled stem almost as broad as the cup at the top, the lower cell being the smaller and often filled with a dark substance, probably manganese compound.

Scattered on the upper surface of the leaf were numerous depressions, (Plate XXIX, figure 3) these in section, were found to be quite different morphologically from what obtains generally in stomata, which they were thought to be when examining the leaf by a pocket lens. The cuticle cells of the leaf were found to continue around the side and bottom of this depression, and no opening or guard cells were detected in the specimens examined. A kind of "anchor cell" was found at the base with one cell running into the depression. It may be that this acts as a clamp to close the aperture leading to the water tissue if such is required. Possibly they are air pores, but more probably contrivances for increasing the area of the cuticle, and the "clamp" to strengthen it during expansion or contraction.

(b) *Function.*—The stomata evidently being few and very minute, (I was unable to detect any in my sections), and the tissue of the leaf quite anomalous, efforts were next made to find out what functions other than those which usually obtain with leaves, are performed by those of this mangrove. Studying the trees carefully in their native habitat it was noticed that the stems almost invariably

were inclined at an angle (more or less acute) with the foreshore. It was at first thought to be due to prevailing winds, but this, however, was found not to be the cause. Next, it was observed that the leaves of all the trees were disposed towards the north,—a case of heliotropism apparently, and the question naturally arose, why? The answer came in the observation, that by such an orientation, the pneumatophores were in shade, and so it worked out that the directing influence was to shade these breathing organs, and in order to get this protection, the stem, but more often the branches, grew in whatever direction this shade was obtainable. It was also noted that wherever the breathing roots became exposed for a length of time to the sun's rays, they perished, and then the branches on that side of the tree died and fell off,—a truly botanical sympathy. Judging from the structure, the storage of a large amount of water is also an important function of these leaves.

The knowledge of this necessity for the natural shading of the pneumatophores can now be turned to some economic purpose. These breathing roots are of great value to the oyster cultivator, as the crop of oysters to be obtained from them is greater than from any material used, such as slates, stone, etc., and consequently great efforts are made to cultivate this mangrove, but it has always been found difficult to start a plantation on a treeless shore, the young plants soon dying or putting on such slow growth as to be almost useless. Since discovering that shade is requisite for the growth of these organs, action is about to be commenced to introduce artificial shade until trees attain some size, or at least sufficient foliage to make its own shade protection, and these efforts will be watched with much interest by the commercial people concerned in oyster culture.

(c) *Economics.*—Cattle eat the leaves with great relish.

6. Breathing Roots.

These may be divided into two portions for descriptive purposes, viz.—(1) that part embedded in the mud, and (2) the portion projecting into the air when not submerged by the tides.

(1) This section shows that the root is surrounded by a broad loose aërenchyma, composed of cells which seen transversely have three arms, and longitudinally appear like a pile of round edged discs. The epidermal and hypodermal layers are persistent in the specimens examined in the field, and so the ventilating system is thus apparently not brought into direct contact with the water of the surrounding mud. (Plates XXX, XXXI, figures 4 and 5.)

(2) The portion of the breathing roots exposed to tide and air, presents, however, some interesting and distinct features from the part embedded in the mud.

In transverse sections (Plates XXXII, XXXIII figures 6 and 7) it is seen that these organs are composed of distinct concentric groups or structure. The root proper, or inner one, is bounded by a continuous ring of phloem cells surrounding the xylem of the bundles which have the usual proxylem and a stele of thin walled vessels and parenchymatous cells. In this part of the plant there appears to be quite an absence of sclerenchymatous cells, as obtains in the concentric rings of the wood. The intermediate circle of peripheral water tissue,—aërenchyma repesenting a primary cortex, is composed of two kinds of cells which go to make up this structure,—spongy mesophyll, loose in the middle but most compact, with smaller cells towards the outer edge, whilst interspersed throughout is found a cell of unusual structure, which transversely shows strengthening bars and perforations, whilst on a longitudinal section appear thick-walled cells often compressed and twinned,

and these can be easily traced on the plates of these roots showing transverse and longitudinal structure. From the nature of this arrangement it is evidently in this portion of the pneumatophore much photosynthesis of the tree is carried out.

The epidermis or outer ring is composed of irregularly shaped thin-walled cells with a tomentum identical in structure with that on the underside of the leaf, but much smaller. In this cuticle, formed by a bulging out of the epidermis and hypodermal layers, are found fairly numerous papillose projections, or special pneumathodes, a section showing these layers of cells to be raised over what is a vacant cavity or air space in direct communication with the ventilating system.

Externally, these appear like so many raised black spots scattered over the surface, with a circular depression on the summit, and supporting what looks to be a circular valve or disc, which from above is apparently made up of three or four concentric growths or rings, but these are lost in a cross section, which shows continuous cells with but yet differentiated from, the contiguous epidermis and hypodermal cells. A section through one of these, when this cap is removed, is not unlike the air pore found in *Marchantia.* It may be that these discs act like a clack valve of a steam engine, and close the orifice when the tide rises and submerges the root, and receding when the air plays round it. But this requires further investigation, as similar markings occur on the ærial roots found on the stem six or ten feet above high water mark. Apparently then, these are pneumathodes or they may be secondary organs of ventilation, of the same nature or function as lenticels.

The tip (Plate XXXIV, figure 8) of this portion of the root is composed of thin walled nucleated parenchymatous cells

which gradually increase in size as they differentiate into the separate structures of the root. The extreme tip is quite closed, nor is there any root cap as obtains in ordinary roots as shown in text books on the anatomy of the phanerogams. The tip of the ærial root found on the trunks high above water mark differs from these in that it has a projection as described above.

7. The Seed.

(a) *Germination* (Plate XXXV, figure 9).—The fruit dropping on the ground quickly sheds its pericarp and the hypocotyl soon begins to grow beyond the bunch of simple hairs or blunt ending, from which roots are sent at varying angles. At their earliest stages of growth they are found to have sufficient power to anchor the cotyledons, as it is only a matter of a short time before a miniature plant appears.

(b) *Seed as a food.*—The aborigines ate freely of the prolific crop of fruits which they roasted before eating.

8. The Timber.

(a) *Economics.*—With such a synonymy associated with this species, it is only to be expected that different accounts are recorded as to the quality of its wood, in fact, varying from "worthless" to "very hard and durable."

The following will give some idea of the confusion surrounding the timber knowledge of the species, and so naturally opinions vary concerning the nature of the wood of *Avicennia officinalis*, Linn., as shown by these extracts:

"The wood of Mangrove, *Avicennia officinalis*, is white, straight in the grain, tough, and elastic, but very perishable.—(*The Forest Flora of New Zealand*, p. 270,—T. Kirk.).

"It is very brittle; used in India for firewood. Major Ford says it is used for mills for husking paddy, rice pounders, and oil mills in the Andamans."—(*Dictionary of the Economic Products of India*, Vol. I, p. 361,—Watt.)

"The wood is valued on account of its durability under water, and as a fuel for heating furnaces. It is preferred to other kinds of wood on the West Coast of India."—(*Pharmographia Indica*, Vol. III, p. 82,—Dymock).

"Timber said to be durable as poles and in other places used for ship-building, etc."—(*The Forests and Forest Cape Colony*, p. 287,—Sim).

"In New South Wales, the wood is valued for stone-mason's mallets, on account of its toughness."—*The Treasury of Botany*," Vol. I, p. 112,—Lindley and Moore).

The timber of the Australian tree may be described as a pale coloured, very hard, heavy, cross laminated timber, inclined to slightly darken on exposure. It has several characteristics that easily differentiate it from any other timber known to me, and these are here described in sequence (*infra*). It is used in New South Wales for knee boats, crooks, and generally in boat-building when strength is required.

I am indebted to Mr. H. J. Swain, B.A., B.Sc., Lecturer, Mechanical Engineeering Department, Sydney Technical College, for the following tests:—

No.	Material.	Size.	Area of Cross Section.	Breaking Load in lbs. per sq. in.	Modulus of rupture in lbs. per sq. in.	Modulus of elasticity in lbs. per square inch.	Rate of Load in lbs. per minute.
1	Grey Mangrove	3·03″ x 3·03″ x 36″	9·18 sq.in.	6610	12850	168000	3860
2	Grey Mangrove	3·02″ x 3·03″ x 36″	9·15 ,,	6620	12900	169000	4000
3	Grey Mangrove	3·02″ x 3·03″ x 36″	9·15 ,,	7070	13800	172500	4000

For comparison the averages of three specimens were—Ironbark 9000; Blue Gum 5000; Burma Teak 6000; Colonial Teak 8000.

(b) *Analysis of the ash.*—An analysis made by my colleague Mr. H. G. Smith, F.C.S., gave the following results:—

The ash was used by early settlers at Port Macquarie in the manufacture of soap, in preference to that of all the other trees in the district. It was probably by empirical means that such a use was found for it, although the practice was quite a common one elsewhere. The percentage of soda as carbonate being so large, it is readily seen how useful such material could be made for such a purpose.

The large amount of alkalis renders the ash easily fusible, and some difficulty was experienced in preparing it in a fit state for analysis; it was necessary to dissolve out the alkalis before all the carbon could be removed.

The percentage of ash calculated on the anhydrous wood was 2·43 per cent. There were no sulphates remaining in the insoluble portion, nor were phosphates detected in the soluble. The amount of silica was very small, and only a trace of iron was present. Manganese was detected, but only in minute traces. The silver precipitates were decomposed by zinc, and in the filtrate bromine was detected but not iodine.

The composition of the ash was determined as follows:—

Potassium sulphate ...	2·26	per cent.
Potassium chloride... ...	19·58	,,
Sodium chloride	7·60	,,
Sodium carbonate	41·61	,,
Calcium phosphate	7·01	,,
Calcium carbonate	9·94	,,
Magnesium carbonate ...	11·73	,,
Silica	0·13	,,
Loss and undetermined ...	0·14	,,
	100·00	

(c) *Macroscopical.*—Viewing a transverse section of a mature tree, (Plates XXXVI, XXXVII, figures 10 and 11) the annual "rings" as obtains in ordinary dicotyledonous stems might be said to be well defined, but with this difference, that the "rings" are not continuous, the break being caused by an intrusion of another "ring," and thus the complete circle is broken.

By forcing the "rings" apart tangentially a good view is obtained of the disposition of the fibres. Each ring of fibres is seen to be at quite a different angle to that in juxta-position to it. Sometimes they run perpendicularly, but more often at varying angles to each opposing ring, (Plate XXXVIII, figure 12).

Dr. Prain's remarks in his "Flora of the Sandabans," 1903, apply equally well to this Australian Mangrove:—

"The structure of the wood is peculiar, in that the fibres of any particular ring of growth do not pass vertically upwards, but instead diverge 'herring-bone fashion" from an indistinct vertical linear raphe, which appears to correspond to the plane of an original branch, at an angle of about 15°, their upper ends blending in a much less definite raphe mid-way between two raphes of divergence. The raphes of divergence of the ring of growth next above and next below any particular ring alternate, so that in weathered trunks, and to a less extent in freshly cut sound logs, a lace-work arrangement of the fibres of the various rings of growth presents itself."

The structure of the timber much resembles what is to-day on the markets as three, four, or five-ply veneer, which can now be shown to be only a copy of nature, for in the manufactured article the fibres of each sheet of wood are at right angles to one another instead of at oblique angles, as obtains in nature, which, is the main reason for the difficulty in splitting.

There is another remarkable feature about this wood, and that is its resistance to splitting radially, for it is impossible to so split a log say three feet or more in length. Tangentially it is much more fissile, and in this direction it is more easily split than any other timber known to me. The aborigines were cognisant of this character, as shown by their preference for it for shield making.

(d) *Histology—Primary or Early, and Secondary Wood.* Many sections were made for examination, and from these, typical samples showing the structure during different periods of growth are here figured and described.

Primary or Early Wood.

(*a*) This is a transverse section of ultimate branchlet measuring 2·5 mm. in diameter. (Plate XXXIX, figure 13.)

(*b*) A larger twig than (*a*) measuring 4·5 mm. (Plate XL, figure 14).

(c) Showing older growth than the two previous ones, measuring 6 mm. in diameter. (Plate XLI, figure 15).

(*a*) Figure 13. This may be described as almost quadrilateral in transverse section, the bundles being parallel to the shape of the outer edge of cortex in a continuous line removed from it about one-third of the diameter, and enclosing the central mass of thin wall structure (hexagonal in section). The space between the cortex and the bundles is composed of a smaller irregularly shaped structure of loose parenchyma, most of the cells near the edge containing a substance not determined, and forming the pro-cortex.

(*b*) Figure 14. This section shows an advanced stage of growth upon that of (*a*). The central mass of vessels, etc. forms a much less proportion of the whole, the bundles are

well defined, the xylem and proxylem well pronounced, and the phloem coloured purple by hæmatoxylon being backed by what is gradually becoming a distinct ring of stone or sclerenchymatous cells, is followed by thin-walled wood parenchyma cells enclosed the whole way round by a narrow ring of original phloem, and this is subtended by a broader band of cortex. Pores may be noted occurring in the radial lines of the xylem. The whole is composed of a perfect regularity of structure.

(c) Figure 15. This shows a centre made up of vessels and a few sclerenchymatous stone cells (in section) and parenchyma, the whole bounded by a complete ring of bundles, with numerous pores in the xylem (red) with interfascicular rays, the phloem (purple) backed by short sclerenchymatous cells followed by a band of wood parenchyma. Now this structure is repeated in a regular manner outwards to the fourth ring, and then is noticed an intrusion of another "ring" which breaks the continuity of the fifth ring. This section is of particular interest because it shows how, even in the early stages of growth, the rays are restricted or limited to the space between the two walls of sclerenchymatous cells, and so are not strictly medullary rays as generally understood; this feature obtains throughout all the secondary wood in the species, and is more fully illustrated in figure 16, *(infra)*. Up to this stage, the rings are entire and evidently annual, but from this out, they become broken.

Secondary Wood—Transverse Section.—(Plate XLII, figure 16) In this section is seen a bifurcated band of thick walled cells forming the barrier to the progress of the rays to continue beyond the limits of each "ring." This wall of sclerenchymatous cells is bounded on either side by wood parenchyma with thin walls, and between these are the wood fibres with small lumen.

In the wood parenchyma are seen groups of (apparently) broken cells. Tracing these back from a two or three years' old twig, they are seen to be the phloem cells of the bundles and stain purple, with haematoxylon, as with other phloems. They are composed of thin walled bast parenchyma and bast stone cells, the latter showing the long axis in the longitudinal section, and with comparatively thin walls, both being filled with what is probably a tannin substance. Combined they make up the remarkable "dottings" on the outer edge of each concentric "ring," which continue to appear almost regularly as the tree attains maturity, and macroscopically examining a piece of timber they appear as rows of pin pricks. I believe these perform all the functions of the ordinary bark of a dicotyledonous plant, as injury to the outer cortex has no effect on the life of the tree.

Tangential Section.—In this view, (Plate XLIII, figure 17) are clearly brought out the different angles or planes in which the fibres run, and the sclerenchymatous cells are seen to be exactly the same shape as in the transverse section, showing that they are short, isodiametric bodies and not elongated. It is due to this particular form that the timber splits so readily tangentially, there not being a length of fibre to give an interlocking strength, or in other words no cross structure such as would occur if the rays ran through and held together the annual "rings." The phloem cells with the broken content *(supra)* are here seen longitudinally.

Radial Section (Plate XLIV, figure 18).—Owing to the twisting of the wood fibres, it is almost impossible to get a section showing the full height of a ray, which vary from uniseriate to multiseriate, such as are seen in figure 17, which shows conclusively how completely the vertical sclerenchymatous ring of cells restricts them to the width

of a "ring" only. In such a case, it seems to me hardly correct to call them medullary rays, for they do not come from the middle of the stem. The phloem of the broken cell contents is as conspicuous as in other sections.

Fibres.—These are distinctly seen in the various sections shown, and microscopically examined are found to belong to the simple variety, the walls being relatively thick, and in the lumen are seen oblique slits. The length is over 1 mm., and these make up 30 per cent. of the wood by nitric acid method.

Results of these Histological Investigations

(*a*) Practically no true medullary rays, as obtain in secondary wood of dicotyledons, are found in the structure, for what must certainly be classed as "rays" yet are not medullary, as they do not extend from the middle to the outer cortex, being quite restricted in their length to the width of each "ring."

(*b*) Bands of vertical walls of sclerenchymatous cells of the round or polygonal or short variety limit the length of the rays,—a feature quite absent in any timber as far as I have been able to ascertain.

(*c*) The phloem cells in regular clusters on the outer edge of each ring, appear to perform the function of ordinary exterior bark, as shown when the tree is ring-barked.

(*d*) The remarkable disposition of the wood fibres.

(*e*) The work of cambium being performed apparently by the wood parenchyma between the wood fibres and the stone cells.

(*f*.) There is nothing in the wood which corresponds with the spring and autumn growths of other dicotyledonous trees.

9. Bark.

This investigation goes to show that all previous published information (*infra*) stating that the bark is used for tanning does not apply to the Australian species, as the outer bark on very young and fully matured trees is so thin and the quantity so small that it would never pay to use it for tanning purposes. The tannin which it contains does not amount to more than 7 per cent. according to an analysis made by Mr. H. G. Smith. This goes to show conclusively that, when it is spoken of—and it often is—as a valuable tannin bark, several species must have been or are included under the specific name. In fact, this one feature alone seems to prove that we have here a distinct and very probably an unnamed species.

Evidently the following data, appearing under the name of *Avicennia officinalis*, do not apply to the Australian species:—

"The bark is astringent and is used by tanners."—(*Pharmacographia Indica*," Vol. III, p. 82,—Dymock).

"The bark is used as a tanning agent."—(*Birdwood, Bombay, Prod.*)

"In Rio de Janeiro, the barks of various species of *Avicennia* are used in tanning leather."—(*Dictionary of the Economic Products of India*," Vol. I, p. 361,—Watt).

"The next important group are the Mangroves, that grow in the tidal creeks, which are said to make most durable sole leather, even better than oak, but there appears to be a prejudice against this tannin in England."—(*Tropical Agriculturalist, Colombo*," 1903-4, p. 2).

"Fair percentage of tannin in this bark."—(*New Plants in Natal*," 1905, Sims).

"The bark is used in tanning."—(*The Forests and Forest Flora of Cape Colony*, p. 287,—Sims).

"Bark used for tanning,"—Birdwood, (*Products of India*, p. 361,—Watt).

"Bark used in Rio de Janeiro for tanning,"—(Surgeon H. W. Hill).

"Bark astringent," (Surgeon Major W. Dymock, Bombay).

A noticeable feature about this tree is that it is impossible to kill it by ring-barking, for trees are to be seen in the Port Macquarie district that have not suffered in the least by such treatment, but are in just as flourishing a condition as if they had never been touched by the axeman. This tree then is an exception to the rule. The fact that this mangrove should live on in spite of this general method of killing trees is, in my opinion, due to each "ring" being in itself a fascicular bundle, consisting of the elements or factors that go to make up such a combination of phloem, xylem, etc. Cutting away then what is regarded as the bark is really only depriving the tree of a ring of an outer cortex, and further the remaining numerous phloem streaks in the individual rings are quite able to carry on the function of that injured on the outside, and so the tree lives,—a character unique as far as my knowledge goes in the botanical world.

10. Concentric Rings and their relation to the age of the tree.

When carrying out an investigation on the fibres of Australian trees, I was particularly attracted by the peculiar disposition of those of this tree, they being quite unlike anything I had previously met with.

Mr. T. Dick of Port Macquarie, N.S.W., who was much interested in the subject of the manufacture of shields from this tree by the aborigines, also drew my attention to the fact that it was most difficult to split this mangrove timber radially. It was these features which caused me to make an investigation of the histology of the timber (*supra*).

Searching for literature in regard to the matter, I found that Mr. A. W. Lushington had drawn attention to the "concentric rings" of *Avicennia officinalis*, as to whether they were annual or not, in the "Indian Forester" for 1893, Vol. XIX, p. 104, to which the Hon. Editor adds a foot note to the effect that these "rings" are not annual, and gives a picture of a section of *Avicennia* wood after Nordlinger, not mentioned in Solereder—the originals of which I am unable to trace. This was followed by a letter in the same journal, Vol. XXIII, p. 413, by Mr. J. S. Gamble, who, whilst giving a list of so-called mangroves, makes a plea for some one to investigate the wood rings of *A. officinalis*, and to ascertain how far, if at all, the curious structure of the wood is caused by periodical phenomena, such as tides, etc.

Mr. A. W. Lushington, of Masulipatum, in the same journal, Vol. XXIV, p. 56, writes in reference to Mr. Gamble's letter *(supra)*, and takes exception to that gentleman's statement that "the rings of *Avicennia* are obviously in no way periodical, for they are not concentric, but run into each other," and on account of those characteristics periodicity cannot possibly exist. He then goes on to attribute this break in the concentric rings to forest fires. Further, he propounds the theory that, possibly, the monthly difference of the tides might have something to do with these rings, owing to the trees being more flushed with water at one part of the month than at another. He next records how he experimented with *Avicennia*, and found twenty-five of these spurious rings after two (2) trees had been cut twenty-five months, and in another thirty-five rings after thirty-five months.

The editor adds a foot-note to the effect that a section may show a different layer of tissue, probably bark, between each layer of wood.

The Madras Report for 1895-96, states:—"It was found in the Kistna District that the annual growth in diameter of the mangrove *(Avicennia)* amounts to nearly an inch, and from one to two feet in height. It is considered the spurious rings are monthly, and are probably due to the different conditions of nutrition caused by the spring and neap tides."

Perhaps the tropical temperatures may cause such rapid growth, but such a rate does not hold for the New South Wales plants. Mr. Dick is a keen observer of nature, so that his data should not be despised, and having visited the locality and examined the tree *in situ*, I think he is correct in his decisions (*infra*).

From observations made by Mr. Dick on the species occurring at Port Macquare, the monthly rate of growth obtained by Mr. Lushington does not hold in Australia, in fact, it appears that a very slow rate of growth obtains in this country.

Port Macquarie in New South Wales is an important centre of oyster cultivation, and this particular mangrove is much used in the culture of that mollusc, so that the tree has necessarily been under close observation by many people for a long time. Mr. Dick writes me in this connection:—

"I have been for a number of years on this river, and working amongst the Mangrove, and I am in a position after my experience of twenty-five years to state that this tree has a very slow rate of growth. Other people, who have been for sixty years in the same locality, also state that the tree has a very slow growth, and that it is not noticeable, being so very, very slow. I, to-day, went to certain trees that had been marked in reference to the fixing of the boundaries of certain of our oyster leases, this marking having been done in 1897; one tree had the broad arrow cut in it, the number of the lease also. Now on examination to-day, the marks are not much altered, and are not overgrown in any way. A

barbed wire fence was attached to a Mangrove in 1895, prior to our taking up the lease, this wire being stapled to the tree; this was found to be covered with the new growth of timber and to a depth of 1 inch. The tree is certainly a long while in the growth, and will live to an enormous age. As regards the side to the water being softer, I find the Mangrove the same as other trees, affected on the side exposed to the sun."

Mr. Dick also informs me in a later letter:—

"I duly received your letter *re* the age and rate of growth of what I call the 'Grey Mangrove.' In reference to the rate of growth, I can only state as before, and that is, that the tree as far as we have found it to grow on this river, is slow in its growth. I planted a large quantity, or should say transplanted them, in a very suitable piece of bottom, and I am going to photograph the rows of trees for you, and will send them down. The trees so far have not averaged one foot per year in height. I have asked a number of people about the growth, and they all say the same—very slow, practically not noticeable. Since starting to write, I have ascertained that it is seven years that the trees have been growing." (Plate XLV, figure 19.)

These data certainly illustrate a much slower growth than that recorded for Indian species, and certainly give colour to my contention that here we have a distinct species from that one. I have visited this locality and examined the latter trees above mentioned, and endorse all Mr. Dick's remarks as regards them. I found that they measured five feet in height and three inches in diameter at the base.—a great disappointment to the oyster cultivator, who planted them as a help in the industry. I have also examined a large number of trees from which the aborigines cut their shields very many years ago, and in every instance only the very slightest growth had taken place wherever shields had been cut, in fact, except that the face from which the shields had been taken, was a little weathered, the actual size of the shield would probably

about fit the space now left, judging from the dimensions of an original shield.

Conclusions.

Reviewing some of Mr. Lushington's theories *(supra)* of the remarkable growth of this tree, my investigations show (*a*) that forest fires do not play the part he assigns to them, and that the break of concentricity is not due to that cause, as fires are not known to have occurred where the trees abound, and yet breaks occur in the ring, and then the stems are so regularly built up by these rings that traces of retardation of growth are rarely perceptible, such as one finds in other trees that have suffered from artificial or natural causes. My correspondent, who has watched hundreds of trees for many years, dismisses this theory as applied to New South Wales trees, as bush fires rarely if ever occur amongst them, and my own personal examination of the trees in this and other districts does not support this theory. It is in the fifth or sixth year of the age of the tree that these breaks in the rings begin to develop.

(*b*) Neither is there evidence forthcoming to support this gentleman's suggestion that each ring or portion of a ring represents a tide, if I understand his idea rightly, for during the known age of certain trees, far more tides must have passed round the tree than are represented by the rings. Sections were made from a tree planted seven years ago, and the number of rings correspond to this number, and (*c*) Mr. Lushington's experiment of finding the number of spurious rings to correspond to the number of months proves that the growth of trees must be very much faster in India than in Australia, for the data given above under the seven years old trees are indisputable.

Finally, I can only say that after giving much thought and attention to the subject, I am unable to advance any definite explanation to account for this remarkable struc-

ture of the timber. I have thought of several, but the most feasible seem to me to be (1) the attaining of a maximum amount of strength with a minimum amount of weight by the disposition of the fibres and breaks in the "rings" required by the large quantity of foliage carried by the tree, and (2) strength to resist river currents and tides. Further, I believe, that each individual "ring" represents a year in the age of the tree, and this is supported at least by authenticated trees planted during the last six or seven years, whilst evidences certainly favour the theory that these trees grow to a great age.

(3) The *sine que non* of the life of the tree is a shading of the roots, consequently trees are often found overhanging the water at an angle that would be dangerous to the life of an ordinary tree, and yet this inclined stem, carrying a great weight of foliage and branches for the shading of the pneumatophores, flourishes. In some instances stems are almost parallel with the mud or water, hence the necessity for great strength in the timber. (Plate XLVI, fig. 20.)

(4) Then, again, the great vitality of the tree is assured by the collective structure of each "ring," and so whatever accident may happen to a part of the tree, there is always left sufficient independent material to carry on the work of leaf formation to procure shade for the pneumatophores, so essential to the life of the tree.

If these are not the reasons for such phenomena of wood structure and growth, then I am afraid it is a case of knowledge without understanding.

Note:—In the discussion which followed the reading of the paper, Mr. J. Nangle, F.R.A.S., explained that this strong and especially built timber failed in reaching the testing figures of the "Ironbark," owing to want of interlocking fibres between each "ring," there being nothing to prevent a sliding of the surfaces. In the case of beams, architects

overcame this defect by placing keys between them, and thus preventing a shearing upon each other when subjected to a great weight.

EXPLANATION OF PLATES XXVII – XLVI.

Fig. 1. Transverse section of a portion of leaf showing central bundle, and neighbouring tissue. × 150.

,, 2. Transverse section of a portion of a leaf showing a depression on the upper surface. × 50.

,, 3. Higher magnification of Fig. 2, showing structure of depression and surrounding tissue. × 150.

,, 4. Transverse section of breathing root below mud surface. × 30.

,, 5. Longitudinal section of breathing root below mud surface. × 15.

,, 6. Transverse section near the tip of air and tide exposed portion of a pneumatophore, but cutting central root. × 30.

,, *7. Transverse section near the tip of air and tide exposed portion of a pneumatophore, but cutting central root lower down than Fig. 6. × 30.†

,, *8. Longitudinal section through tip of a pneumatophore. × 30.

,, 9. Series showing germination of seed (natural size).

,, 10. Transverse section of a trunk of a tree (reduced.)

,, 11. Transverse section of trunk of tree (enlarged from 10).

,, 12. Tangential view of split wood showing disposition of fibres.

,,*13. Transverse section of primary growth. × 30.

,, 14. Transverse section of later growth. × 100.

,,*15. Transverse section of 6 years old wood. × 15.

,, 16. Transverse section of secondary wood. × 35.

,, 17. Tangential section of secondary wood. × 35.

,, 18. Radial section of secondary wood. × 35.

,, 19. Seven years' old "Grey Mangrove" trees, 5 feet high.

,, 20. "Grey Mangrove" out-spreading over air and tide exposed portion of breathing roots.

* Coloured Plates.

† Plate XXXIII read Fig. 6 instead of Fig. 4.

ORIGIN OF THE HELIMAN OR SHIELD OF THE NEW SOUTH WALES COAST ABORIGINES.

By THOMAS DICK.

(Communicated by Mr. R. T. BAKER, F.L.S.)

[With Plates XLVII - LI.]

[*Read before the Royal Society of N. S. Wales, November 3, 1915.*]

Introduction.

THE heliman or shield was a weapon of defense, perhaps the principal one, of the natives of this continent. It had different names, according to the locality of origin, but heliman was the most common; nor was its shape restricted to one special form. The wood from which it was made had to possess certain qualities, such as hardness and strength, and what was of great importance to these men of the Stone Age, it had to come away readily from the parent tree.

The observations recorded in this paper show that the wood of the Grey Mangrove, *Avicennia officinalis*, Linn. possessed these qualities in a marked degree, and so this tree was selected above all others by the aborigines for the manufacture of their shields, as can now be seen by the scars on the living trees of the Port Macquarie District. A very limited number of other trees appear to have been employed for this special article, for only one or two are known along the coast, viz., the Fig, (*Ficus* sp.), and the "Stinging Tree," (*Laportea gigas*). But these trees do not appear to have been used when a suitable *Avicennia* was near at hand, in fact, from my observations, I should say that probably only when this Mangrove had been worked out, did the natives turn to other sources of supply. The

evidence of shield-cutting from this timber is so well defined that the writer is puzzled to know how this important part of the work of the stone age has been overlooked by previous writers.

On investigating the result of the work of the stone axe on the Grey Mangrove, a vast field was opened up, as not only was the work done by the stone axe revealed, but there was also brought to light, the method and locality where these axes were made. To those who may follow up the investigation, it will be found that by thoroughly examining this mangrove reclamation where the aborigine at one time roamed and worked to get his shield, stone chippings, broken axes, broken wedges, hammers and shell-fish form a large proportion of these deposits. Many of these areas are now covered by such alluviums in many places, and to a great depth; this, combined with other facts, goes to prove that this part of the coast was inhabited at a much earlier date than is usually allowed for.

In the Stone Period the shields were cut with stone implements only, and this period must have extended over a very long time, as shown by the variety of shapes of the axes and cutting stones found at the bases of the trees, from very crude unground stones with cutting edges made by splitting only, to the ground edged implements. The former are actually the shivers off water worn boulders, weighing over 100 lbs., and in many cases so many shivers have been taken from the original stones that the unused part now only weighs a few pounds.

With the arrival of the white man, the Iron Age was introduced into Australia, and the native naturally took early to the use of the iron axe, and marks on the trees easily distinguish the shields obtained by its means from those of the stone axe.

The late John Stuart Dick of Port Macquarie had often seen the natives removing the shields in the early days of the settlement by stone tools only. As the natives learned to value the steel axe very readily, it was only a short time when many of them had steel tomahawks, and Mr. Dick saw many shields removed by steel tools as well. It was the information given by this Mr. Dick that led to the search amongst the trees, as he often drew my attention to those which were marked.

Mr. Ernest Harold Dick, also of Port Macquarie, gave the following interesting account:—

"I was walking past a mangrove swamp, and saw a full blooded native, one that I knew from Rollands Plains, in the act of removing a shield from a tree. The tree was a grey mangrove, and the native had cut the rabbet with a steel tomahawk and was driving bluff wedges of wood into the rabbet, and after driving a number of the wedges, the shield eventually came off."

This shows that what was done with stone was continued with iron, for the native soon realised the superiority of the white man's iron axe over his stone one.

My own observations, towards which I have been helped by a daily occupation on the waters of Port Macquarie, have now extended over a period of twenty-five years.

Method of Cutting the Shield.

From the evidence available, it would appear that the tree generally selected from which to remove a shield was one of even growth, as will be seen in the plates given in this paper. That the native was familiar with the peculiarities of this particular species of timber must now be accepted, also that he was aware at the same time of the lifting power of the wedge, and further he made these stone wedges a certain shape, in order to get this lifting power. The *modus operandi* was as follows:—Having marked out the piece to be removed, by placing the shield

carried by the native against the tree, the rabbet was next cut. This rabbet was most remarkable, and goes to show the resourceful ingenuity of the aborigine. The wedge used was of special stone found in the district, and shaped similarly to a gad used for bursting stone, only the point was not made fine, but on the contrary, it was blunt and would not enter timber. The rabbet was cut to take the point of this wedge, and to allow the wedge to be driven into it, and so derive great lifting power. The rabbet would be cut for a depth of two or three inches, and would be about one and a half inches wide at the surface, and half an inch at the bottom. This rabbet was cut right round the shield, and besides being used to drive the wedges in, it also cut the rings of the timber of the tree, and so allowed the piece to come away readily. Eight or nine wedges were driven into the rabbet, and when the tree was hard, there would be a number of wedges destroyed and dropped, and these can be found at the present time by digging round old trees. To get the lifting power the wedges were made practically double the width of the rabbet into which they were to be driven.

The shield, having been removed, would be carried to the camp, where with smaller wedges and cutting stones its manufacture would soon be finished. As the tree had peculiar rings in the timber, the native simply drove small wedges into the rings and so trimmed the shield down to the required thickness.

In this district almost every Grey Mangrove tree of suitable size has been made to yield a shield, and in many cases more than one shield has been taken from the same trunk. The tree also sent up shoots which eventually were also cut, this new growth even after woundings lived to a great age, so that there are clumps of trees showing the work of several generations. On one tree nine different

shield marks were counted, the tree being sixteen feet in girth. The manner in which the wounds had distorted the tree was most interesting. Judging by other shield marks and a knowledge of this species of tree, it was estimated that some of the shields had been removed over five hundred years ago.

In cutting the rabbet, two kinds of stones were evidently used, one of them was a shaped and ground axe made from stone, and another was formed to fit the hand, and was not ground, the edge being kept keen by chipping the blade. In several instances ground stone axes from which part of the face had jumped out, were found at the foot of the trees. As most of the other species of trees that the native had at his disposal were not suitable for getting shields, this mangrove tree of this district was in the greatest demand, and when the supply was exhausted, the native had to resort to the Fig, for several fine specimens, showing shield scars, have been procured. On investigating it was found, however, that it was very seldom that other than mangrove was used.

Reasons for Selecting this Tree.

In the introduction, reference is made to the preference for this tree over all others by the aborigines, and from my investigation into the subject, I think there can be little doubt that it was owing to the fact that its timber splits tangentially more readily in this direction than that of any other tree in the bush, and indeed this timber is almost impossible to split radially, a feature that would be a great desideratum in material for the construction of a shield.

Description of Plates.

Plate XLVII.—An aboriginal heliman or shield, now in the possession of Mr. T. Dick. It is made from the Grey Mangrove with stone implements and is twenty-nine inches in length and eleven inches in width at the centre, being

three-quarters of an inch in thickness and tapering to three-eighths of an inch at the edges. Although very old, the timber is in good preservation and very strong.

It was used as a means of self defence from attack by spears and boomerangs. These shields were known by various names, in the interior mostly "elamong," on the coast "heliman," and in Queensland "valaman."

Two holes were cut in the centre of the shield, and a vine twisted and worked in as a handle,—the vine was called "Whipi," *Malaisia tortuosa*, Blanco, which was also used for the purpose of climbing trees. Some shields, especially those made in Queensland, had the handle worked out of the wood used in making the shield.

Plate XLVIII.—A group of Grey Mangroves at the present time. No description is necessary with this picture, the shield mark being so defined on the tree on the left as to leave no room for argument. It will be seen that a similar mark is carried out on the tree on the right, and that the shield has been cut much earlier, the piece being decayed completely out. In the rear are a number of trees with shield marks going back to a long period. Both of the trees in the foreground have had two shields removed, but are not visible. The picture was taken in a group of many hundreds of trees so marked. Both of the two trees shown illustrate the method of how the tree survives this wounding, and how successive generations may secure their shields from the same tree. It will be noticed that each tree has a decided lean to the left, and immediately above the shield mark will be seen a new growth. Round the wound is also a new growth which is nourishing the new shoots the tree has sent out. This new growth round the wound heals very evenly, as shown on the left, and continues until eventually the head of the tree decays and falls off. In time the new tree is again attacked by

the native (probably the descendant of the previous operator), hence the most remarkable results as shown on some of the trees. When shields had been cut right at the bottom, peculiar results were brought about, and where two or more shields had been removed the trees were found to have completely split open, so that where there was one tree there are now three or four.

Plate XLIX.—The rabbet having been properly cut to the required depth (this being about three inches) the two natives are now engaged driving the peculiar bluff wedges into the special rabbet, and the man on the left is handing up the wedges to the native on the right, who is driving them in with a stone hammer or maul. Several of the wedges have broken, others chipped; these are dropped as shown, and to-day are the specimens found in all areas where this work has been done.

Plate L.—Having been successful in getting the wedges to draw in the rabbet the shield has been forced off, and the native is lifting the piece away from the tree. The thickness of the piece can be seen in this picture, also the defined mark left on the tree. This mark is what has been traced right through the mangrove areas in this district. It will be seen that no fragments of timber are clinging to the shield, and that it has come away from the tree clean of all splinters.

Plate LI.—A fine specimen of the work of the stone age, which by appearance was done about one hundred years ago. The mark of the shield which was removed is well defined, and part of the rabbet is still showing at the bottom.

CERUSSITE CRYSTALS FROM BROKEN HILL, NEW SOUTH WALES AND MULDIVA, QUEENSLAND.

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(Contribution from the Australian Museum.)

With Plates LII – LIV, and Six Text-figures.

[*Read before the Royal Society of N. S. Wales, November 3, 1915.*]

CERUSSITE FROM BROKEN HILL.

OF the mineral species found in the oxidised zone of the Broken Hill lodes none are better developed or more characteristic than cerussite; indeed anyone with a little experience can at once distinguish the cerussite of Broken Hill from that of any other locality. Short descriptions of the mineral have been published by Mügge,[1] and Spencer,[2] and a fairly detailed account by Marsh.[3] Some years ago, a paper in which crystals of cerussite from Broken Hill were described, appeared in the Records of the Australian Museum,[4] but since that time the Trustees have acquired some fine specimens in the collection of Mr. George Smith and from the Dixson (formerly the Aldridge) collection, and I am now in a position to supplement the previous account, and to clear up some points which were formerly obscure. In the interval I have obtained from the authors reprints of the important papers by Goldschmidt on the cerussite of Mapimi, Mexico,[5] and by Hubrecht on the cerussite of Sardinia,[6] and am therefore able to compare

[1] Mügge, N. Jahrb. Min. II, 1897, p. 78.
[2] Spencer, Min. Mag., XIII, 1901, p. 39, f.n.
[3] Marsh, Trans. Austr. Inst. Min. Eng., IV, 1897, pp. 141 – 147.
[4] Anderson, Rec. Austr. Mus., VI, 1907, pp. 407 – 410.
[5] Goldschmidt, N. Jahrb. Min. Beil.-Bd. XV, 1902, pp. 562 – 593.
[6] Hubrecht, Zeits. Kryst., XL, 1905, pp. 147 – 188.

the crystallographic features and the complicated twinning of the three occurrences. The cerussite was found on the roof, sides, and floor of vughs in the ore masses, associated with manganic iron oxide, anglesite, smithsonite (zinc carbonate), embolite, and galena; in some specimens small crystals of galena are seated on the cerussite, indicating that the former results in these cases from secondary deposition. In habit the crystals vary somewhat. Simple crystals are rare, twins being the rule with *r* (130), or *m* (110) as twin plane. When doublets occur they are, so far as I know, always twinned on the *r* law and the crystals are either of arrow-head shape (Plate LIV, fig. 1),[1] or prismatic along the vertical axis.[2] A group of arrow-head twins scattered on a matrix of oxide of iron (Plate LIV, fig. 4) forms a specimen of rare beauty; it will be observed that the crystals are generally attached to the matrix by the point of the 'arrow.' The reticulated or dendritic groups, which are the commonest of all, and which may be described as tabular on *b* and elongated parallel to the *a* axis (Plate LIV, fig. 2) are combinations of twins on *r* and on *m*, and may consist of a dozen or more individuals, forming a polyet[3] of a complicated nature. The present paper is mainly concerned with the elucidation of the interesting features presented by these polyets.

Measurements were made on a Goldschmidt two-circle goniometer, which is well adapted for the investigation of complicated groups such as are here described. Measurement is greatly facilitated by the fact that the vertical axes of the several individuals (segments) composing the polyet are parallel, so that all necessary angular determinations can be readily made with one mounting of the group

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[1] Anderson, *loc. cit.*, pl. lxxvii, figs. 1, 2. [2] *Id.*, *ibid.*, pl. lxxvi, fig. 3.

[3] I am not certain whether this term has previously been used for a group of several twinned crystals, but an English equivalent for the German '*vielling*' is necessary, and polyet seems a suitable word.

on the goniometer. To discover the twin relations of two or more segments it is sufficient to determine the relative positions of the zone [*c b*] in the various segments; this zone is fortunately the best developed, and, in most cases an average of several measurements can be obtained. The orientation is most conveniently given by fixing the relative positions of the normals to *b* in each segment, that is by comparing ϕ_o of the individuals with reference to a 'first meridian.'

For twins on *m* the angle between the *b* pinacoids is 62° 46′ or 117° 14′ (180° − 62° 46′), for twins on *r*, 57° 18′ or 122° 42′. It will be noticed that these angles approach 60°, the means being 60° 2′ and 119° 58′ respectively. Now Goldschmidt and Hubrecht found (*loc. cit.*) that the angles between the twinned segments do not in every case conform to the theoretical requirements, but show a slight divergence, so that the angle between the two segments approaches more nearly to 60°, that is the angle between *m* doublets decreases and between *r* doublets increases. Goldschmidt sees in this a proof that the zone planes are planes of force (*Kraftebene*), and the face-normals directions of force (*Kraftrichtungen*), which endeavour to place themselves in parallelism much as the magnetic needle places itself in the magnetic meridian. Thus Goldschmidt says (*loc. cit.*, p. 583):—"By mutual diversion the meridians [*c b*] of the separate individuals of a polyet approach the positions 0°, ± 60°, ± 120°, ± 180°. The group approximates to hexagonal symmetry." Hubrecht (*loc. cit.*, p. 149) puts the matter very clearly and concisely, "This divergence [*Ablenkung*] was regarded as an argument in favour of the view that face-normals are directions of force which bind the particles together and unite crystals in parallel or twin position, that moreover zone planes are to be regarded as planes of force, and that such directions of force and planes of force influence one another when they have nearly

the same direction and that in this case they endeavour to take a middle position." Goldschmidt then, and following him Hubrecht consider that twinning is to be explained by the tendency of lines and planes of force in the two individuals to place themselves parallel. In Text Fig. 1,

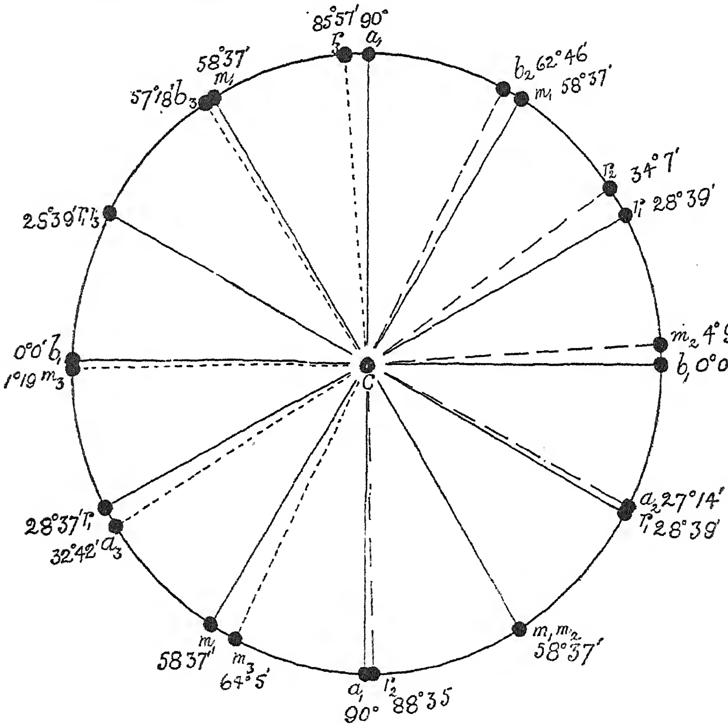

Fig. 1.

we have a stereographic projection of a cerussite crystal I in the conventional position, showing the poles of the pinacoids and the *m* and *r* prisms, the corresponding normals being drawn in full lines, with, on the right, the same poles and normals (long-dashed lines) of a crystal II twinned to I on *m* (110), and, on the left, the poles and normals (short-dashed lines) of a crystal III twinned to I on *r* (130). The

vertical axes, that is the normals to the c pinacoids, have placed themselves parallel in the three segments and in II one zone plane [$c\,m$] and normals in that zone are ranged parallel to the corresponding plane and normals in I, while in the r twin III one zone plane [$c\,r$] and its normals have placed themselves parallel to the corresponding plane and normals of I, whence the twin relations result. It is apparent that if II and III be rotated slightly cum-clockwise, the normals to b_2 and m_1 r_2 and r_1, m_2 and b_1, a_2 and r_1 and r_2 and a_1, also r_3 and a_1, b_3 and m_1, m_3 and b_1, a_3 and r_1, m_3 and m_1, respectively, will be brought closer together. This will have the effect of bringing b_2 closer to b_1 and separating b_3 and b_1 more widely, that is the angle $b_1 \wedge b_2$ becomes less than the precise 62° 46′ and $b_1 \wedge b_3$ greater than 57° 18′. In each case therefore the angle $b_1 \wedge b_x$ comes nearer to the value 60°. In general none of the axes will coincide but will take a 'middle position.'

Although the existence of 'planes of force' and 'directions of force' in the zone planes and face-normals is more or less an assumption, there is no doubt that crystals do possess a directive force by virtue of which the crystal particles, whatever these may be, are marshalled into a regular formation; this is proved by the existence of liquid crystals. Moreover there is nothing unorthodox in speaking of parallelism of axes or directions which are not crystallographically equivalent, for we know that crystals do exhibit parallel growths of this kind; we may cite Goldschmidt's 'hetero-twins,' in which inequivalent but similar and similarly directed axes place themselves parallel or nearly parallel.[1]

Whether Goldschmidt's hypothesis is valid or not it is important to discover whether a similar divergence to that

[1] Goldschmidt, Zeits. Kryst., XLIII, 1907, pp. 582–586; Goldschmidt and Paul, *Ib.*, XLVI, 1909, p. 471; Ford, Amer. Journ. Sci. XXX, 1910, pp. 16–23.

observed by him and by Hubrecht is shown by cerussite from other localities. In my former paper (*loc. cit.*, p. 409) I gave the result of measurement made on two groups of four crystals twinned in pairs on *r*. "Denoting the four segments by I, II, III, IV, we have I and II, likewise III and IV twinned on *r*, but although the orientation of III and IV relative to I and II is nearly the same in the two groups, I have not been able to prove it due to twinning on any known face. Appended are the angles obtained between the *b* pinacoids of the four segments.

(1) $b_1 \wedge b_2 = 57^\circ\ 13'$ (calculated for *r*-twin 57° 18')
$b_1 \wedge b_3 = 61\ \ 26$ (calculated for *m*-twin 62° 46')
$b_1 \wedge b_4 = 4\ \ 4$

(2) $b_1 \wedge b_2 = 57\ \ 18$
$b_1 \wedge b_3 = 61\ \ 54$
$b \wedge b = 4\ \ 38$"

At the time this was written I had not seen the papers by Goldschmidt and Hubrecht and was not aware that these crystallographers had observed divergences of the same order, and it is one of the objects of this paper, now that better material is available, to extend the investigation in order to see if possible whether any general rule covering these anomalies applies to the cerussite of Broken Hill and Muldiva, where similar polyets are found. It may be remarked that a departure from the exact angle demanded by the twin law has been observed in other minerals than cerussite; thus Des Cloizeaux[1] found that in albite twins faces theoretically parallel may be inclined to one another at an angle varying from 40′ to 1° 40′, and Miers[2] observed a similar variation in twins of proustite and pyrargyrite.

Description of Groups.

Group I. (Plate LIV, figs. 5, 6).—This specimen from Block 14, is a triplet on *r*, II and III being twinned to I;

[1] Des Cloizeaux, Man. de Minéralogie, I, p. 520.
[2] Miers, Min. Mag., VIII, 1888, pp. 74—76.

it is too large for measurement on the reflecting goniometer, I, which is elongated parallel to *b*, being 9 cm. long by 5 cm. in depth, but approximate measurements with a contact goniometer leaves little doubt as to the relations of the three segments. In Fig. 6 I is represented as lying on the *b* pinacoid, but in all other similar figures in this paper the crystals are placed with the vertical axis perpendicular to the plane of the paper as this is the best position for showing the orientation. On I is a small arrow-head twin the exact relation of which to the larger segments could not be determined; a little plumose galena is crystallised on the cerussite.

Group II (Plate LII, fig. 1, Text Fig. 2).—This and the succeeding three groups from the Proprietary Mine are off a large specimen consisting of crystals elongated parallel to the vertical axis, and measuring to about 7 by 1 cm.; the matrix is stalactitic limonite and short tapering crystals of smithsonite are attached to the cerussite. The group consists of four segments twinned in pairs on *r*, the forms present being *b* (010), *m* (110), *r* (130), *x* (012), *k* (011), *i* (021), *v* (031), *y* (102), *p* (111). The faces in the prism zone are strongly striated vertically, but the terminal faces

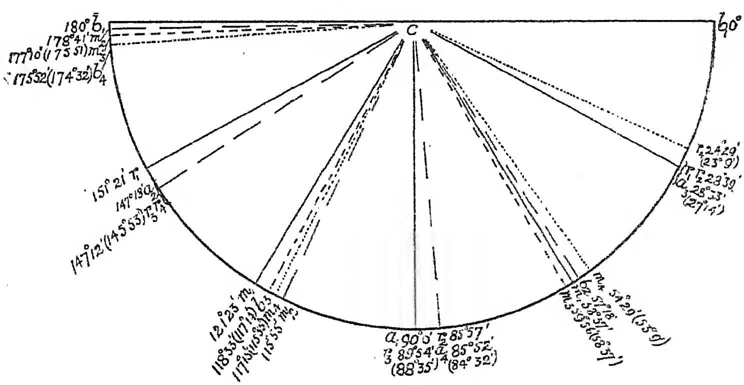

Fig. 2.

are mostly smooth and brilliant, giving good reflections. In the following and succeeding tables the best measurements, suitably weighted, are used to fix the position of the *b* pinacoid and in the accompanying text figures the orientation of the various twin segments is indicated by the position of the normal to *b*; V_o is the mean of the actual goniometric readings, ϕ_o gives the angular distance from the first meridian (position of segment I).

Segment.	V_o.	Limits.	Number of Observations.	ϕ_o
I	117° 18′	117° 16′ – 117° 22′	3	0° 0′
II	174 28	174 17 – 174 32	5	57 11
III	235 51	235 44 – 235 56	3	118 33
IV	293 10	293 10 – 293 11	2	175 52

Thus we have the following angular relations:—

I $\wedge$ II = 57° 11′ (*r*-twin 57° 18′). I $\wedge$ III = 61° 27′ (*m*-twin 62°46′).
III $\wedge$ IV = 57° 18′. II $\wedge$ IV = 61° 19′.
II $\wedge$ III = 61° 22.

The divergence therefore from the position of an *m*-twin is in the sense demanded by Goldschmidt's hypothesis. In Text Fig. 2 the orientation is shown in stereographic projection, it being assumed that I and II and III and IV are inclined to one another at the precise angle of twinning; the position which the poles of III and IV would occupy if these segments were twinned on *m* to I and II respectively are indicated by the angular values enclosed in parentheses. This projection shows clearly that the chief zones are brought more nearly into parallelism than they would be if the exact angle $b \wedge \underline{b}$ were maintained; for example r_1 (r_2), a_3 are practically coincident as are a_4 and r_2, r_3 and a_1, a_2 and r_4. Indeed one might describe III and IV as hetero-twins to I and II in which the vertical axes and the zones [c *a*] and [c *r*] are parallel.

Group III.—This is very similar to Group II and does not require particular description. The orientation is as follows:—

Segment.	V_c	Limits.	Number of Observations.	ϕ_o
I	351° 0′	350° 59′ – 351° 2′	5	0° 0′
II	48 19	48 14 – 48 26	6	57 19
III	109 5	108 59 – 109 6	5	118 5
IV	166 14	166 11 – 166 17	2	175 14

Thus I is twinned to II on r (meas. 57° 19′, calc. 57° 18′) and III to IV on r (meas. 57° 9′) while $b_1 \wedge b_3 = 61° 55'$ and $b_2 \wedge b_4 = 62° 5'$. The direction of divergence is the same as before and is in accordance with Goldschmidt's hypothesis.

Group IV (Plate LII, fig. 4, Text Fig. 3).—This is essentially similar to the two preceding groups, but the segments are united in a different manner.

Segment.	V_o	Limit.	Number of Observations.	ϕ_o
I	72° 52′	72° 48′ – 72° 56′	4	0° 0′
II	130 7	130 5 – 130 9	7	57 15
III	250 41	250 34 – 250 46	7	177 49
IV	128 0	127 56 – 128 4	7	55 8
(V				117 14)

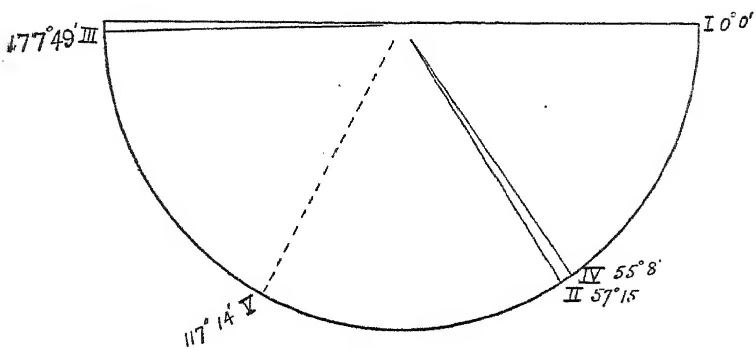

Fig. 3.

V is a hypothetical segment twinned to I on *m*; to assume its existence is permissible as the position is a possible and probable one. We then have the following relations:—

$$\left.\begin{array}{l} \mathrm{I} \wedge \mathrm{II} = 57^\circ\ 15' \\ \mathrm{III} \wedge \mathrm{IV} = 57\ \ 19 \end{array}\right\} r\text{-twin } 57^\circ\ 18'$$

$$\left.\begin{array}{l} \mathrm{III} \wedge \mathrm{II} = 59\ \ 26 \\ \mathrm{IV} \wedge \mathrm{V} = 62\ \ 06 \\ \mathrm{III} \wedge \mathrm{V} = 60\ \ 35 \end{array}\right\} m\text{-twin } 62^\circ\ 46'.$$

Here again the two *r*-twins I and II, III and IV conform very closely to the theoretical angle, while III to II and III and IV to the assumed segment V (twinned to I on *m*) show the required divergence.

Group V.—In this the segments are unequally developed, I and II being much larger than III and IV.

Segment.	V_o	Limit.	Number of Observations.	ϕ_o
I	164° 21′	164° 19′ – 164° 23′	3	0° 0′
II	221 39	221 33 – 221 42	7	57 18
III	286 58	286 56 – 287 0	2	122 37
IV	281 30	281 29 – 281 30	2	117 9

In this group, therefore, I is twinned to II and to III on *r* (angles 57° 18′ and 57° 23′, calc. 57° 18′), and I is twinned to III on *m* at an angle of 62° 51′ (calc. 62° 46′), the variation from the calculated angles being within the limits of observational error.

Group VI (Plate LII, fig. 2, Text Fig. 4).—This consists of thirteen segments twinned on *r* and extended in the direction of the vertical axis to form a columnar aggregate measuring about 8 by 2 cm.; the edges formed by the *r* faces project horizontally, radiating from the central part of the column. The group may be described as a polyet of arrow-head twins on *r* elongated parallel to the vertical axis and united by the points of the arrows. Reflections are moderately good, but for some of the segments the measurements were rather meagre, and a high degree of

accuracy for the orientation is not claimed. The chief forms present are *b* (010), *r* (130), *y* (102), *k* (011), *x* (012), the two last much striated; *i* (021), *o* (112), and *p* (111) are also represented, and *m* appears as striæ in *r*.

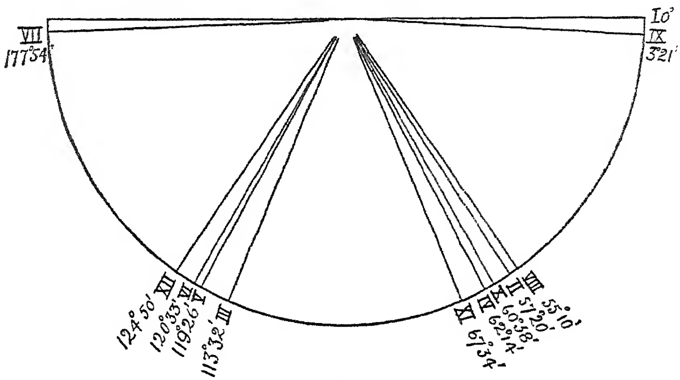

Fig. 4.

Segment.	γ_0	Limits.	Number of Observations.	ϕ_0
I	316° 58'	316° 51' – 317° 3'	4	0° 0'
II	14 18	14 8 – 14 28	5	57 20
III	70 30	70 25 – 70 33	5	113 32
IV	19 12	18 48 – 19 24	5	62 14
V	76 24	76 2 – 76 40	4	119 26
VI	77 31		1	120 33
VII	134 52	134 42 – 135 3	7	177 54
VIII	192 8	192 5 – 192 11	2	55 10
IX	320 19		1	3 21
X	17 36	17 35 – 17 36	2	60 38
XI	24 32	24 23 – 24 40	5	67 34
XII	81 48		1	124 20

The *r*-twins can be easily distinguished as those tabulated below:—

Segments.	Meas. $b \wedge \underline{b}$	Calc. for *r*-twin
I, II	57° 20'	57° 18'.
IV, V	57 12	
VI, VII	57 21	
VII, VIII	57 15	
IX, X	57 17	
XI, XII	57 16	

From inspection one would be led to think that II is twinned to III on *r*, forming a triplet with I similar to the triplet VI, VII, VIII, but the angle between II and III is only 56° 12′; the angles between the others agree well with requirements. Of possible *m*-twins we have the following:

Segments.	Meas. $b \wedge \underline{b}$	Calc. for *m*-twins.
IV, XII	62° 36′	62° 46′
VI, IX	117 12	117 14
VII, X	117 16	117 14

It should be remarked that here as in other cases all the twinned pairs are not independent; if VI and VII and IX and X respectively are twinned on *r*, and if VI is twinned to IX on *m*, then VII and X must be twinned on *m*.

There are also a number of individuals which approximate to twin position:—

Segments.	Meas. $b \wedge \underline{b}$.	
I, IV	62° 14′	Calc. for *m*-twin 62° 46′
II, V	62 6	
V, VII	58 28	Calc. for *r*-twin 57° 18′
IV, VI	58 19	
X, V	58 48	
X, VI	59 55	
III, VIII	121 37	Calc. for *r*-twin 122° 42′
IX, XII	121 29	

All these diverging angles show the required variation except the angle between II and III, but where so many segments are concerned, the mutual relations are not so clear as in simpler groups; one cannot see the wood for the trees as it were. The text figure brings into prominence the fact that the crystals group themselves round directions at about 60° apart, namely 0° 25′ (mean position of I, VII, IX), 60° 35′ (mean position of VII, II, X, IV, XI), and 119° 35′ (mean position of III, V, VI, XII). We shall see later that this orientation, which shows that the grouping is not haphazard, is characteristic.

Group VII (Plate LII, fig. 3).—This and Groups VIII and IX are all portions of one large specimen, and they naturally show some family resemblance; they belong to the reticulated type, the crystals being short in the direction of the vertical axis, tabular on *b* and elongated parallel to the a axis. Group VII consists of seven individuals twinned on *m* and *r*, the angular relations conforming fairly well to the requirements of the two laws. Segment I, 5 cm. long, is larger than the others, II and III are fairly large, the others comparatively small; there are a number of still smaller individuals whose position could not be ascertained and which have been omitted. The whole group is very fragile and most of the terminations are wanting. The commonest faces belong to the forms *c* (010), *m* (110), *r* (130), *k* (011); *x* (012), *i* (021), *v* (031), *y* (102), *p* (111) and *w* (211) were also recognised. In spite of frequent striation the signals were on the whole good and the orientation of the crystals is well established. In the figure the crystals are idealised but their relative dimensions and positions are preserved. Segments which are parallel though not in contact are numbered alike and the measurements obtained from them are combined to find the mean angles given in the subjoined table.

Segment.	V_0	Limits.	Number of Observations.	ϕ_0
I	206° 53′	206° 45′ – 207° 10′	11	0° 0′
II	329 32	329 26 – 329 35	7	122 39
III	212 21	212 13 – 212 35	8	·5 28
IV	324 9	323 59 – 324 14	8	117 16
V	269 29	269 24 – 269 34	4	62 36
VI	274 56	274 50 – 275 2	3	68 3
VII	332 4	332 2 – 332 6	3	125 11

The twins may now be readily recognised:—

Segments.	Meas. $b \wedge \underline{b}$	
I, II	57° 21′	Calc. for *r*-twins 57° 8′
III, V	57 8	
VI, VII	57 8	

Segments.	Meas. $b \wedge \underline{b}$	
I, IV	62 44	Calc. for *m*-twins 62° 16′
I, V	62 36	
II, III	62 49	
V, VII	62 35	

Thus all the segments are united by the two laws and the deviation from the exact angle of twinning is nowhere more than 11′.

Group VIII (Plate LIV, fig. 3, Plate LII, fig. 5, Text Fig. 5).—This instructive group consists of thirteen individuals, some of which are represented by several crystals in parallel position, and finely illustrates the complicated twinning and reticulated or dendritic structure of the mineral. It also exemplifies well the manner in which 'secondary' and 'tertiary' twins are apt to form in the re-entrant angle of the 'primary' twins and so to fill up this angle. The individuals I, II and III are much larger than the others, I having a length of about $5\frac{1}{2}$ cm.; these three may be described as 'paragenic' twins, that is they formed an embryonal triplet and grew up together, while the others are 'metagenic' twins which came into existence after I, II and III had attained some size. A small, typical arrow-head twin IV and V is planted on I; it has the forms *b* (010), *r* (130), *x* (012), *k* (011), *y* (102), *p* (111), *s* (121). This *r*-twin pair is not in any exact relation to the main group except that the direction of its vertical axis is the same. Two small crystals VII and XII, which are not exactly twinned to one another (angle 63° 14′, calc. 62° 46′), are attached to the IV and V pair, but, like the latter, these are not in any precise twin relation to any of the others, although VII is very nearly parallel to IX and XII to VIII; the other twin relations are well established. The drawing (Plate LII, fig. 5) is partly diagrammatic; the stippled portion in the bottom left corner of the figure belongs to a twin group whose vertical axis is not parallel to that of Group VII.

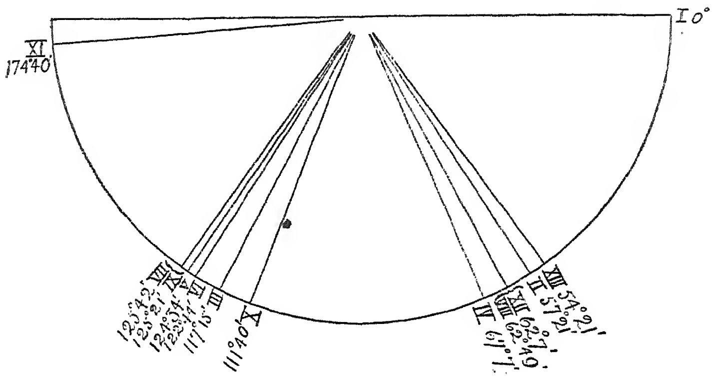

Fig. 5.

Segment.	V_o	Limits.	Number of Observations.	ϕ_o
I	286° 9'	286° 7' – 286° 10'	5	0° 0'
II	343 30	343 22 – 343 37	4	57 21
III	43 24	43 20 – 43 29	7	117 15
IV	353 16	353 11 – 353 28	8	67 7
V	50 43	50 36 – 50 53	6	124 34
VI	48 53	48 52 – 48 53	3	122 44
VII	51 30	51 14 – 51 46	2	125 21
VIII	348 58	348 52 – 349 6	5	62 49
IX	51 51	51 47 – 51 59	5	125 42
X	37 59	37 49 – 38 7	3	111 40
XI	100 49	100 43 – 101 4	4	174 40
XII	348 16	348 13 – 348 19	2	62 7
XIII	340 30	340 30	2	54 21

Disentangling the twins we have the following results:—

Segments.	Meas. $b \wedge \underline{b}$	
I, II	57° 21'	
I, VI	57 16	
III, XI	57 25	Calc. for *r*-twin 57° 18'.
IV, V	57 27	
X, XIII	57 19	
I, III	62 45	
I, VIII	62 49	
II, XI	62 41	
VIII, IX	62 53	Calc. for *m*-twin 62° 46'.
III, XIII	62 54	
X, XI	63 00	

The irregularities in this list are not large and several are in the wrong direction, if support for Goldschmidt's view is sought. Of pairs which are doubtfully in twin position we have the following:—

Segments.	Meas. $b \wedge \underline{b}$
V, XII	62° 27′
VII, VIII	62 32
V, VIII	61 45

Here the divergence from the theoretical angle is in the right direction, but we cannot lay much stress on it.

Group IX (Plate LIII, fig. 1).—The small group, $1\frac{1}{2}$ cm. approximately in length, has a general resemblance to the last described. Here I and V, and perhaps II, are paragenic twins, the others metagenic. The forms represented are *b* (010), *m* (110), *r* (130), *x* (012), *k* (011), *i* (021), *v* (031), *y* (102), *p* (111).

Segment.	V_o	Limits.	Number of Observations.	ϕ_o
I	329° 9′	329° 6′ – 329° 11′	6	0° 0′
II	32 1	31 56 – 32 7	5	62 52
III	143 38	143 37 – 143 40	5	174 29
IV	94 48	94 43 – 94 53	3	125 39
V	26 27	26 24 – 26 31	10	57 18
VI	86 42	86 41 – 86 42	2	117 33

Twin relations:—

Segments.	Meas. $b \wedge \underline{b}$	
I, V	57° 18′	Calc. for *r*-twin 57° 18′.
I, II	62 52	Calc. for *m*-twin 62° 46′.
I, VI	62 28	
II, IV	62 47	
III, V	62 49	

The segment VI is the only one which shows a noticeable departure from the true twin position; unfortunately only scanty measurements were obtained but the signals were good and 18′ is too great a discrepancy to be attributed to observational error. Crystal VI, if twinned at all, is

evidently twinned to I, and its position lends support to Goldschmidt's contention.

Group X (Plate LIII, fig. 4, Text Fig. 6).—This group, which is about $3\frac{1}{2}$ cm. in greatest diameter, was attached to a limonitous matrix; in general appearance it resembles Groups VII, VIII, IX. The forms identified are *c* (001), *b* (010), *m* (110), *x* (012), *k* (011), *i* (021), *v* (031), *y* (102), *p* (111), *o* (112), *s* (121); in addition a face which may belong to *q* (023) was observed once (ρ meas. 25° 48′, calc. 25° 44′). A possible new dome (059) gave a single measurement (ρ meas. 22° 0′, calc. 21° 53′), but it requires confirmation.

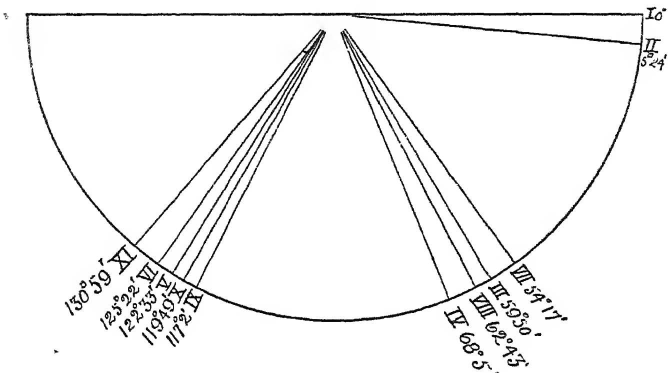

Fig. 6.

Segment.	V_o	Limits.	Number of Observations.	ϕ_o
I	116° 3′	116° 7′ – 116° 25′	10	0° 0′
II	121 37	121 28 – 121 44	8	5 24
III	176 3	176 1 – 176 5	3	59 50
IV	184 18	184 11 – 184 24	8	68 5
V	238 46	238 41 – 238 54	11	122 33
VI	241 35	241 32 – 241 37	4	125 22
VII	170 30	170 29 – 170 30	2	54 17
VIII	178 56	178 48 – 179 6	12	62 43
IX	233 15	233 3 – 233 27	11	117 2
X	236 2	236 1 – 236 2	2	119 49
XI	247 12	247 9 – 247 16	2	130 59

Twin relations:—

Segments.	Meas. $b \wedge \underline{b}$	
I, V	57° 27′	Calc. for *r*-twin 57° 18′.
II, VIII	57 19	
III, IX	57 12	
IV, VI	57 17	
I, VIII	62 43	Calc. for *m*-twins 62° 46′.
II, IV	62 41	
IV, XI	62 54	
VI, VIII	62 39	
VII, IX	62 45	

The only crystal unaccounted for in the above scheme is X; it approximates to the position of an *r* twin to VIII (meas. $b \wedge \underline{b}$ 57° 6′), which would make it a witness against Goldschmidt's supposition. A small arrowhead twin is planted on I and II, one segment being parallel to II, the other with VIII; an embryonal *r*-twin has settled on II, one segment of the twin placing itself paralled to II.

Cerussite from Muldiva.

In the Australian Museum collection there are two specimens of azurite from the Paisley Shaft, Muldiva, Chillagoe District, Queensland; the azurite, finely crystallised,[1] is on a limonite matrix, and seated on the azurite are small crystals of cerussite, many of them twinned. The cerussite groups are scarcely larger than a pin's head, but the faces give good reflections in the main, and four groups were measured with the following results.

Description of Groups.

Group I (Plate LIII, fig. 5). This is a triplet of a type common with cerussite and aragonite. The faces, idealised in the drawing, belong to the forms *c* (001), *a* (100), *b* (010), *m* (110), *r* (130), *y* (102), *p* (111). The value of ϕ_0 for the three segments is 0° 0′, 62° 41′ and 117° 18′ respectively,

[1] Anderson, Rec. Austr. Mus., VII, 1909, p. 278.

which shows that I is twinned to II and to III on *m* (calc. angles 62° 46′ and 117° 14′).

Group II (Plate LIII, fig. 2). Here the *r* law predominates, the group consisting of two arrow-head twins united by their points; measurement however reveals that while I is twinned to II on *r* it is twinned to III on *m*, hence also IV is twinned to II on *m*, so that here we have a fine example of four individuals united by the two laws. The faces in the prism zone are so strongly striated that their readings barely suffice for identification, but the faces of *p* and *y* give good readings, so that the orientation can be relied upon to within a few minutes. The value of $\phi_\circ$ for I, II, III, IV respectively is 0° 0′, 57° 9′, 62° 30′, 119° 42 and we have the following relations:—

Segments.	Meas. $b \wedge \underline{b}$	
I, II	57° 9′	Calc. for *r*-twin 57° 18′
III, IV	57 12	
I, III	62 30	Calc. for *m*-twin 62° 46′
II, IV	62 33	

This result does not throw much light on the general question as the variations in the *r*-twins are away from 60° and in the *m*-twins towards 60°; in any case the measurements are too few.

Group III (Plate LIII, fig. 3).—This group, which is rather more complicated than the preceding two, has the forms *a* (100), *b* (010), *m* (110), *r* (130), *k* (011), *y* (102), *p* (111); the prism zone is striated vertically, *b* and *r* inter-oscillating, while *m* is very narrow.

Orientation.

	I	II	III	IV	V
$V_\circ$	102° 55′	160° 12′	165° 33′	228° 16′	225° 45′
$\phi_\circ$	0 0	57 17	62 38	125 21	122 50.

The twinning is therefore as follows:—

Segments.	Meas. $b \wedge \underline{b}$	
I, II	57° 17′	Calc. for *r*-twin 57° 18′
I, V	57 10	
I, III	62 38	Calc. for *m*-twin 62° 46′
III, IV	62 43	

and there is no marked divergence from the true twin position.

Conclusion.

Generally speaking the variations from the true twin position are in the same direction as in the crystals investigated by Goldschmidt and Hubrecht, but this is not always the case, and it is doubtful whether any far-reaching conclusion can be drawn on the basis of these observations.

NOTES ON EUCALYPTUS (WITH DESCRIPTIONS OF NEW SPECIES) No. IV.

By J. H. MAIDEN, F.L.S.

[*Read before the Royal Society of N. S. Wales, November 3, 1915.*]

The proposed new species are:—

1. *E. Dundasi*,
2. *E. Sheathiana*,
3. *E. Websteriana*,
4. *E. Flocktoniæ*,
5. *E. confluens* (W.V.F.) Maiden,
6. *E. Houseana* (W.V.F.) Maiden.

1. E. DUNDASI, n. sp.

Arbor silvas formans, "Blackbutt" vocata. Foliis pedunculatis, angusto-lanceolatis, acuminatis, plerumque apice falcata, nitentibus, coriaceis, venis obscuris. Petioliis 1 – 1·5 cm. longis, foliis 8 – 9 cm., minus 1 cm. latis. Alabastris perfecte apertis non visis, sessilibis vel pedicello brevissimo, petiolo communi paullo plano et circa 1 cm. longo. Cupula circa ·5 cm. longa, gracile, in apicem angustata. Operculo acuminato, conico et dimidio cupulæ æquilongo. Antheris paralleliter aperientibus, dorso glandula magna juxta apicem. Fructibus cylindroideis, medio paullo constrictis, ·7 cm. longis et circa ·4 cm. latis orificio. Valvarum apicibus non super orificium.

This is a tree of which Dr. L. Diels gave me a few leaves, buds and fruits (all entirely glabrous) in the year 1901, together with the following particulars. It is his No. 5454, and is "a tall tree forming forests," in the neighbourhood of Dundas, W.A., where it goes under the name of "Blackbutt."

I may say that the name of "Blackbutt" is, in Western Australia, usually applied to *E. patens*, Benth. of the well-

watered South West, but, in the later settled arid goldfields area, the name is given more or less loosely to several (perhaps many) species, as it is a common character of trees of that region to have somewhat smooth trunks, with more or less dark flaky bark on the butt, and these are called "Blackbutts."

The Dundas specimens may be described as follows:

Juvenile leaves not available.

Mature leaves.—Only eleven leaves were received. They are pedunculate, narrow-lanceolate, acuminate, usually with a hooked tip, shiny, equally green on both sides, moderately rich in oil, venation scarcely visible, margin thickened, midrib the only obvious vein, lateral veins roughly parallel and acutely attached to the midrib. Petioles 1–1·5 cm., length of leaves 8–9 cm., breadth under 1 cm.

Flowers.—Buds not fully developed are alone available. Brownish-black in colour, sessile or with a very short pedicel, the common petiole slightly flattened and about 1 cm. long. The calyx-tube about ·5 cm. long, slender, and tapering very gradually; the operculum pointed, conical, and about half the length of the calyx-tube. The anthers are immature but they open in parallel slits and have a large gland at the back near the top.

Fruits.—Three fruits are available, picked off the ground and somewhat weather-worn. Cylindroid, slightly constricted in the middle, with some indistinct ribs, in very low relief below the constriction. ·7 cm. long, and about ·4 cm. broad at the orifice. Tips of the valves not appearing above the orifice.

Habitat.—The village of Dundas, Western Australia, after which the species is named, is situated fifteen miles south of Norseman, on the Esperance road, and was the

centre of the early mining operations on the Norseman field.

Affinities.

I have not obtained additional material although I have tried, at intervals extending over a number of years. I cannot identify it with any described species and I think it should be given a name. A figure of such material as is available will be given in my "Critical Revision" in due course.

A species cannot be satisfactorily defined unless its affinities are indicated, and if the material and data (*e.g.*, concerning the timber) fall short of completeness, the suggestions as to affinities must of necessity be tentative.

The present is one of the narrow hook-leaved species of which there are not a few more or less uncinate, *e.g.*, *E. uncinata*, Turcz. (in which the hooks were thought to be characteristic of the species); *E. oleosa*, F.v.M. (especially some of its narrow-leaved forms); *E. angustissima*, F.v.M.; *E. calycogona*, Turcz. var. *gracilis*, Maiden; *E. cneorifolia*, DC.; *E. Moorei*, Maiden and Cambage.

1. With *E. Clelandi*, Maiden. This is another goldfields "Blackbutt," and it is depicted at Part XVI of my "Critical Revision." The species are quite distinct, *E. Clelandi* being glaucous, with dull foliage, ribbed buds (particularly the opercula). The fruits of *E. Clelandi* are nearer than the buds to those of *E. Dundasi*, but the former are not constricted in the middle and otherwise differ somewhat in shape. The buds of *E. Clelandi* are immature, and the immature anthers are, in that state, not dissimilar to the immature anthers of *E. Dundasi*.

2. With *E. oleosa* F.v.M. At Plate 66, fig. 2 of this work a narrow-leaved form of this species is depicted, which displays considerable superficial resemblance to the present form. It is an aberrant form of *E. oleosa* but one hesitates

to give it a varietal name. It differs from *E. Dundasi* in the anthers and also in the buds and fruits.

2. E. Sheathiana, n. sp.

Arbuscula gracilis nunc 10 feet alta, erecta, cortice longis tenuibus lamellis secedente. Ramulis glaucis, plerumque subteretibus sed ultimis ramulis angulatiusculis. Foliis maturis obscuro-viridibus, rigidissimis petiolatis (petiolis 1 - 1·5 cm.) lanceolatis, paullo falcatis usque ad 8 cm. longis et 2 vel 3 cm. altis. Venis lateralibus patentibus. Venis haud prominentibus. Foliis valde oleosis. Floribus plurimis. Umbellis usque ad 7 capitulo, pedunculis 1 cm. pedicellis dimidio æquilongis. Operculo fere hemisphaerico, umbonato, plus dimidio cupulâ æquilongo. Cupulâ conoideâ plerumque 2-angulata. Antheris amplis, paralleliter aperientibus, glandula dorsum fere adhaerente. Fructibus subcylindroideis, maturis non visis.

A specimine culta solum nota.

A slender young tree, 10 feet or more high, at the present time, erect in habit, the bark falling off in long thin flakes (ribbons).

Glaucous, branchlets generally round, though ultimate branchlets somewhat angular.

Juvenile leaves not available.

Mature leaves.—Dull green of the same colour on both sides, rather rigid, petiolate, (petioles 1 – 1·5 cm.), lanceolate, only slightly falcate, up to 8 cm. long and 2 or 3 cm. broad. Lateral veins spreading, roughly parallel, disposed at an acute angle to the midrib. Venation not very prominent, the leaves covered with oil-dots, and evidently rich in oil.

Flowers.—Very floriferous, umbels leaf-opposed to the last leaf, the umbels up to seven in the head with peduncles of 1 cm. and pedicels of half that length. The operculum pointed when half ripe, but when ripe nearly hemispherical

and with an umbo, rather longer than half the length of the calyx-tube which is conoid, has (usually) two angles, and tapers into the distinct pedicel.

Filaments pale yellow or cream-coloured, which dry orange-red and exhibit a pretty contrast with the cream-coloured anthers. Anthers large, creamy-white, opening in parallel slits, the gland nearly filling up the back, and the filament attached almost at the base.

Fruits.—Subcylindroid, but not seen ripe. Thin, defined rim. The tips of the valves, now represented by a persistent style and unexpanded stigma, will when ripe probably become awl-like and will protrude beyond the orifice, in this respect becoming reminiscent of *E. oleosa*.

Known only from a cultivated specimen in the King's Park, Perth, W.A. (The late Mr. J. Sheath, Superintendent up to 1913). Mr. Sheath informed me that he received the seed from "the Eastern Gold Fields near the South Australian border" (of Western Australia).

He further informed me it had been sent to him as *E. erythronema*. I have received additional specimens from the same plant from Mr. Sidney William Jackson, of Sydney, and from Dr. F. Stoward, Government Botanist of Western Australia, whose attention I had invited to the plant.

I name this plant in memory of Mr. Sheath, a first class horticulturist, who was keen on the cultivation of native plants.

Affinities.

This species belongs to the Macrantheræ, of which there are many members, and, in absence of the fruits, I am unable to indicate any close affinities.

3. E. Websteriana, n. sp.

Frutex 6–10 pedes altus. Folia immatura glauca, breve petiolata, fere rotundata vel apice obtusa, ad 3 cm. diametro. Folia

matura petiolata, glauca utrinque aeque viridia, crassa, obovata ad fere spathulata, aliquando emarginata, margine lata et incrassata, venis non prominulis, patentibus. Petioli ·5 – 1 cm. longi. Folia 2 – 4 cm. longa et 1·5 – 2·5 cm. lata. Alabastri gracile pedunculo 1 cm. longo, pedicellos dimidio aequilongos ferente. Cupula hemisphærica. Operculum hemisphærico-conoideum. Antherae in loculamentis parallelis dehiscentes, filamentis basi adherentibus, apice glandula. Fructus pedunculati, pedicellati, fere hemisphærici, plerumque circiter 9 cm. diametro. Margo latissima planaque, valvarum apicibis exsertis. Valvae plerumque 4.

Habitat Coolgardie, Western Australia.

Species ad *E. leptopodam* vergit sed incerte ponatur.

A shrub six or ten feet high. The branchlets round and the bark deciduous.

Juvenile leaves.—Yellowish-green, slightly or wholly glaucous, shortly petiolate nearly circular or with a blunt apex, up to 3 cm. in diameter as seen, venation moderately prominent, spreading, the lateral veins roughly parallel, intramarginal vein scarcely evident.

Mature leaves.—Petiolate, glaucous, equally green on both sides, thick, obovate to almost spathulate, sometimes emarginate, venation hardly visible, spreading, with the intramarginal vein distinctly removed from the edge, the thickened margin remarkably broad, pale-coloured. Petioles ·5 to 1 cm. Leaves 2 – 4 cm. long, and 1·5 – 2·5 cm. broad.

Flowers.—Buds on a slender peduncle of 1 cm. supporting slender pedicels of half that length. Calyx tube hemispherical, operculum hemispheric-conoid.

The anthers open widely in quite lateral parallel slits, filament attached at base, a small gland at the top. It flowered on September 16th, 1900, and was observed to flower each year during the same month.

Fruits.—Pedunculate and pedicellate, remarkably hemispherical. The fruit usually a hemisphere, with a very broad, flat rim, the tips of the valves protruding, but not greatly. Valves usually four. Most of the fruits I have seen are about ·9 cm. in diameter, but I have one 1·1 cm. in diameter with a depth similar to that of the other fruits; in consequence its appearance is more tazza-like.

Habitat.—Near Coolgardie, Western Australia, associated with *E. torquata*, Luehmann. (See p. 109, Vol. I of my Critical Revision). (Mr. now Dr. C. L. Webster).

These two species grow on a range of hills about one hundred feet high above the surrounding country. The range runs almost due east and west; the country consists mostly of iron-stained gravel and boulders lying on decomposed country rock. *E. Websteriana* occurs four miles east of Coolgardie, at Coolgardie (Toorak), and ten miles west of Coolgardie, near the old Southern Cross road and railway line.

Affinities.

In the present state of our knowledge this is a "strong" species, that is to say, we do not know its close relations.

1. With *E. leptopoda*, Benth. The nearest approach to the remarkable fruit of *E. Websteriana* is a Tammin, W.A. specimen of *E. leptopoda*. (See fig. 8, Plate 73, part xvii, Critical Revision). But the juvenile leaves of the two species are sharply different, those of *E. leptopoda* being very narrow. The mature leaves also are very different. The flowers are much more numerous in *E. leptopoda*, and the anthers are similar.

2. With *E. Oldfieldii*, F.v.M. The anthers of the two species are very similar. (See Plate 73.) I do not trace any other resemblances.

3. With *E. squamosa*, Deane and Maiden. In this species the filament is attached slightly at the back but the anthers of the two species are otherwise very similar. (See Plate 73). There is some flattening of the rim in *E. squamosa*, and the shape of the buds (without the filaments), is not dissimilar, but I do not trace other resemblances.

4. With *E. pyriformis*, Turcz. In this species the gland is a little more forward, otherwise the anthers of the two species are much the same. I see no other resemblance.

4. E. Flocktoniæ, n. sp.

(Syn. *E. oleosa*, F.v.M. var. *Flocktoni*, Maiden.)

In Part xvi of my "Critical Revision," p. 185, with Plate 69, I more fully described a Western Australian Eucalypt which I had originally described in "Journ. W.A. Nat. Hist. Soc., Vol. iii (1911), under the name *E. oleosa*, F.v.M. var. *Flocktoni* (*Flocktoniæ*).

I am of opinion that it is worthy of specific rank, and therefore propose the above name for it. As I have, *loc. cit.*, compared and contrasted it with *E. oleosa*, F.v.M., *E. falcata* Turcz., *E. decurva* F.v.M., *E. torquata* Luehm., and *E. incrassata* Labill., and in the present series of notes with *E. Cooperiana* F.v.M., it would appear to be sufficiently discriminated. At the same time it is one of those species concerning which additional information would be acceptable.

In addition to the localities already quoted by me, I have it from Gnowanerup, thirty miles east of Brome Hill, Great Southern Railway, Western Australia (W.C. Grasby).

The seedlings of *E. Flocktoniæ* are remarkable, and may thus be described from the earliest stages.

Hypocotyl long, wiry and angular, crimson. Cotyledons bisected, green on the back, with sometimes a purple tip. Stem angular, crimson, with prominent oil glands. First

leaves narrow linear, ***alternate.*** They afterwards become opposite. As development proceeds, and while the leaves are opposite, they become decurrent in a remarkable degree. I regret it is not possible, at this place, to figure them.

Its affinities in this respect are with *E. salmonophloia*, F.v.M., the young leaves of which are however glaucous.

It resembles *E. Gillii* Maiden in the early stages, but the leaves do not then become decurrent.

5. E. CONFLUENS (W. V. Fitzgerald) Maiden, n. sp.

Folias maturas solum, alabastros non perfecte maturos et fructus habemus, sed planta a specie descripta quaque differe videtur. Arbor ramulis teretibus, apicibus paullo angulatis. Foliis maturis utrinque nitentibus, angusto-lanceolatis, subfalcatis, petiolatis, petioliis circa 2 cm. longis, lamina circa 1 dm. longa et plerumque 1 cm. lata. Venis obscuris. Alabastris circa 8 mm. longis, operculo cupulâque sub-conicis et fere symmetricis. Staminis inversis, antheris paralleliter dehiscentibus, dorso glandula. Fructibus turbinatis v. conoideis, sessilibus vel pedicello circa 1 mm, pedunculo communi minore 1 cm., usque ad 7 capitulo, circa 5 cm. longis latisque.

The available material of this plant is very scanty, consisting of mature leaves, with nearly ripe fruits attached, and a few not perfectly ripe buds picked up from the ground. It is a tree. In spite of the paucity of the material, I have, after careful consideration, come to the conclusion that Mr. Fitzgerald's view that it is undescribed is a correct one. Ampler material will be available some day.

Branchlets round, slightly angular at the tips.

Mature leaves.—Pale-coloured, shiny on both sides, narrow-lanceolate, slightly falcate, petiolate, petioles about 2 cm. and laminæ about 1 dm., with an average width of about 1 cm. Venation very faint, the lateral veins very slender, attached to the midrib at about 60°, the intra-marginal vein close to the edge.

Flowers.—Buds about 8 mm. long, nearly symmetrical as regards the calyx-tube and operculum, both of which are sub-conical. There is sometimes a pedicel of 1 mm. The rim between calyx-tube and operculum is well-defined. Stamens inverted, the anthers opening in parallel slits, gland at the back, filament attached not quite half way up.

Fruits.—Turbinate or conoid, not seen quite ripe, sessile or with a pedicel of about 1 mm., on a common peduncle of under 1 cm., up to 7 in the head, about ·5 cm. long and the same in breadth, a well-defined narrow rim, slightly domed, tips of valves protruded beyond the orifice, and, when ripe, they will doubtless be well exsert.

Habitat.—"Restricted to the sandstone and quartzite ranges, table-lands and sandy foot-hills. On the shales of Mounts House and Clifton the tree life is largely restricted to *E. confluens* and *Grevillea heliosperma.* Occurs on the conglomerates of Mount Behn." (Fitzgerald in "Kimberley Report").

Beyond the above, all that has been published by Mr. Fitzgerald is a small-scale photographic illustration with the words "a narrow-leaved tree; of much wider distribution (than *E. Mooreana* (W.V.F.) Maiden, see this Journal XLVII, p. 221) especially north-east of the King Leopold Ranges."[1]

Affinities.

It is evidently a strong species in the present state of our knowledge, and additional material must become available before one can usefully indicate its relationships.

6. E. HOUSEANA, (W.V.F.) Maiden, sp. nov.

Arbor alta, altitudinem 80 feet attinens, aetate opposito-foliata florescens. Folia juvenia fere amplexicaulia, petiolis brevibus vel absentibus, latissime lanceolata ad fere ovata, basi cordata, apice

[1] "Western Mail," (Perth, W.A.) 2nd June, 1906.

obtusa, pallida saepa glauca, 8 – 12 cm. longa, 6 – 7 cm. lata. Venae patentes, venis principis fere parallelibus, margine crassata. Folia matura petiolata, alternata, falcata, petiolis 2 cm. longis, foliis ad 16 cm. longis et 4 cm. latis. Alabastri, pedunculis brevibus leniter planis, floribus sessilibus vel fere sessilibus, 4 – 7 capitulo. Operculum hemisphæricum circiter dimidio cupula subangulare aequilongum. Antherae aperientes in fissuris parallelibus, versatiles, dorso glandula magna. Fructus non vidimus.

"Amongst the tallest of the tropical species, occasionally reaching a height of 80 feet."

Particulars as to habit, bark and timber not available.

Juvenile leaves.—The following description has been drawn up from specimens in the flowering (or rather plump bud) stage. They represent, as far as we have them at present, the juvenile leaf stage; at the same time, they are mature to the extent that they are contemporaneous with the inflorescence.

Opposite, almost stem-clasping, the petioles being very short or absent; very broadly lanceolate to nearly ovate, cordate at the base, apex blunt-pointed, margin sometimes undulate, pale coloured, or entirely glabrous. Length 8 – 12 cm., width 6 – 7 cm.

Venation spreading, the principal veins roughly parallel, and making an angle of approximately 60° with the midrib. The margin thickened, the intramarginal vein well removed from the edge, the venation distinct, particularly on the lower surface.

Mature leaves.—(Petiolate, alternate, lanceolate, falcate, with petioles of 2 cm., and leaves up to 16 cm. long and 4 cm. wide. Venation distinct, the foliage pale-coloured and glabrous and the two surfaces scarcely to be distinguished from each other.)

Flowers.—Buds with short, slightly flattened peduncles, the individual flowers sessile or almost so, 4 to 7 in the head as seen. Opercula hemispherical, about half the length of the calyx-tube, which tapers only slightly, and which is usually sub-angular.

(Filaments red on drying. Anthers open in parallel slits, attachment of filaments versatile, large gland at back.)

Fruits not seen.

Habitat.—"In swampy and wet sandy localities, associated with the coarser kind of grasses were *E. Houseana* and *E. ptychocarpa.*" (Fitzgerald in "Kimberley Report," p. 12).

Type.—Isdell River near Mount Barnett Homestead, Kimberleys, North Western Australia. No. 1014, collected by W. V. Fitzgerald, May, 1905.

The sentences in brackets ( ) have been drawn up from specimens (No. 1357) collected at the base of the Artesian Range, Kimberleys, by Mr. Fitzgerald.

I attribute the following four specimens to this species:—

1. Scientific Expedition of Prof. W. Baldwin Spencer (and others) from Darwin to the Roper River, Gulf of Carpentaria, July—August, 1911. At Cullen Creek, Prof. Spencer collected a specimen with glaucous foliage, twigs and buds. Leaves sessile but hardly stem-clasping; flowering while the leaves are still opposite. The leaves as much as 15 cm. long and half as broad.

Then I have three specimens from Pine Creek (Railway) Northern Territory.

2. Collected by Dr. H. I. Jensen, Government Geologist, Darwin, in August, 1913. His label reads "Sessile leaf, white bark, (? smooth bark—J.H.M.), small flower and fruit (no fruit available—J.H.M.) rather crooked branches." Close to type.

3. A similar specimen from E. J. Dunn, Pine Creek Railway, same date, also in bud and leaf.

4. Specimen in leaf, bud and flower from Pine Creek, J. H. Niemann, August, 1904. This differs from the type, and Nos. 2 and 3, in having distinct pedicels to the flowers. There is a slight umbo to the operculum, probably because the bud is fully developed. The leaves are mostly narrower-lanceolate than the type, and most have distinct, though very short, petioles.

Affinities.

This is another of the few species which flower in the opposite-leaved or juvenile stage.[1] If described from the type only, it might have been looked upon as a homoblastic species, but the additional material I have quoted shows that, like *E. praecox* (*loc. cit.*) it is heteroblastic, like the vast majority of species of this genus. We can only say that it is an example of retarded heteroblasty.

Other instances of retarded heteroblasty in Eucalyptus are

E. Risdoni, Hook. f. See Plate 32 of my "Critical Revision of the Genus Eucalyptus."

E. Gillii, Maiden. See Plate 67, *op. cit.*

E. cinerea, F.v.M. See Plate 89, *op. cit.*

E. cinerea, F.v.M. var. *multiflora*. Plate 90, *op. cit.*

E. melanophloia, F.v.M.

In the absence of a complete suite of specimens and full data as regards *E. Houseana*, I am only able to suggest relationships to the following species at present.

1. With *E. alba*, Reinw. The flower-buds of *E. Houseana* may resemble those of *E. alba* a good deal. Exceptionally the leaf-blade may resemble that of *E. Houseana* in shape and venation, but that of *E. alba* is not sessile at any stage, not cordate at the base, and is often gross in size. Speaking

[1] Compare, this Journal, XLVIII, 424, (1914).

generally, the foliage of *E. alba* is not pale-coloured whether arising from glaucousness or not. Both species flourish in moist, low-lying localities.

2. With *E. clavigera*, A. Cunn. It differs from this species in the hairiness of the leaves (particularly) in young specimens, so common in *E. clavigera*, in the numerous flowers, in the great length of the peduncles and pedicels and in the clavate shape of the buds of *E. clavigera*. The shape of the leaves and the venation may, exceptionally, be a good deal similar in the two species.

Appendix.—The name *Houseana* was used by Mr. Fitzgerald in the "Western Mail," Perth, W.A. of 2nd June, 1906. No description of the plant was ever published. A small scale photograph was accompanied by the following words:—"*Eucalyptus Houseana*, W.V.F. after Dr. F. M. House, is among the tallest of the tropical species, it occasionally reaching a height of 80 feet. This tree usually occurs on well-grassed plains between the Isdell and Charnley Rivers."

Following are notes on species already published.

1. E. ANGOPHOROIDES, R. T. Baker, Proc. Linn. Soc. N. S. Wales, xxv, 676.

This species is described as from Colombo, N.S.W., and Towrang, N.S.W.

Some years ago I received from Mr. Baker specimens (in bud) from Towrang, which he attributed to this species and which I attributed to *E. Stuartiana*, F.v.M. var. *parviflora*, and still hold that view.

Recently, having received certain specimens from Mr. R. H. Cambage which had been collected by Mr. E. C. Andrews, at Wyndham, on the Pambula-Bombala road, I went into the matter again, and find that they are identical with Mr. Baker's *Colombo* specimens, and I agree with him

as to the validity of his species so far as the Colombo specimens are concerned. Further search at Towrang reveals no *E. angophoroides*, but confirms the previous determination of *E. Stuartiana.*

The error is to be regretted, and I would point out the inconvenience of giving more than one locality for a type.

The combination of the two species is perpetuated in my notes of *E. Stuartiana*, F.v.M. at page 68, part xxiv of my "Critical Revision of the genus Eucalyptus," now in the press, but the type was distributed before I could point out the confusion.

I have also received this plant under the name of "Cabbage Box" from Mr. William Dunn from Yourie, about thirty miles westerly from Bermagui, on the Tuross waters. The locality is useful, as we do not at present know the range of this species.

2. E. CALYCOGONA, Turcz., new for Queensland.

I have dealt with this species in Part iii of my "Critical Revision," and constituted two varieties, *gracilis* (*E. gracilis*, F.v.M. partim) and *celastroides* (*E. celastroides*, Turcz.)

These varieties run into each other, and I compared them[1] with the view of ascertaining if they could be kept apart as species, but failed.

Normal species.—The angular budded and fruited form of the normal species seems very distinct at first sight, but there is a perfect series of transition forms with var. *gracilis*. There seems to be no important differences in the size of the three forms. The two varieties are trees of small or medium size. *E. calycogona* is less well known, but Mr. Walter Gill, Conservator of Forests, Adelaide,

[1] Journ. W.A. Nat. Hist. Soc., III, 169, (1911).

sends me a photograph of a tree twenty-five feet in height and Mr. Max Koch says that it is a tree of thirty feet at Cowcowing, Western Australia. Some forms of var. *gracilis* perhaps showing hybridism, may be larger.

Additional localities (normal species) are "Mallee," Parilla, near Pinnaroo, near the South Australian-Victorian border, with juvenile as well as mature foliage, flowers and fruits (W. Gill). Murray Bridge to Callington, S.A. (J. M. Black). "White Mallee," Sea Lake, Mallee Country, Victoria (C. French, Jr.) Mildura, a form intermediate between *E. calycogona* and var. *gracilis* (W. S. Campbell).

Var. CELASTROIDES, Maiden.

Perhaps specimens from Stamford Hill, Port Lincoln, S.A. (J.H.M.) and Fowler's Bay, S.A. (Dr. R. S. Rogers) may be looked upon as forms intermediate between this and var. *gracilis*. A little coarser than var. *gracilis*, fruit larger than var. *gracilis*, and the calyx distinctly angled, though not so conspicuous as in the normal form. The urceolate fruit of var. *celastroides* is often a useful guide.

Var. GRACILIS, Maiden.

Mueller's type of *E. gracilis* came from the Murray River, S.A. The oil dots of the buds are prominent, and a tendency to an angled calyx-tube is nearly always present. There is some variation in this form in regard to the size of the fruits and the length and thickness of the pedicel, which is not surprising, considering its wide range. It varies a good deal in regard to the quantity of oil in the leaves.

Mr. Max Koch, referring to trees at Cowcowing, W.A., speaks of a small cylindroid fruited specimen as follows:—"A tall tree of fifty or sixty feet high, trunk with rough persistent bark, upper branches smooth. Known as 'Morrel.' It grows in forests amongst Gimlet (*E. salubris*, F.v.M.) and Salmon Gums (*E. salmonophloia*, F.v.M.), and is more plentiful than the other so-called 'Morrel.'"

The use of the name "Morrel," which is one of the most used names in Western Australia, is referred to in my "Critical Revision of the genus Eucalyptus," Part xv, pp. 166-7. It is usually applied to *E. oleosa*, F.v.M. var. *longicornis*, F.v.M.

Mr. Fred. Brockman, then Chief Surveyor of Western Australia, and whose knowledge of the trees of that State was very extensive, in an interesting interview,[1] suggested hybridism in regard to the "Morrel." He suggests that the Yate (*E. occidentalis*, Endl.) from the south coast of Western Australia and the Morrel from the Eastern district of Western Australia (*E. oleosa*, F.v.M. var. *longicornis*, F.v.M.) probably have met say in the latitude of Katanning, and "from the common point a process of hybridising has proceeded spreading northward until Yate is lost in Morrel, and southward until Morrel is lost in Yate."

The late Mr. Henry Johnston, Surveyor General of Western Australia told me that he had given the descriptive name "Yorrel" to a supposed hybrid between York Gum (*E. foecunda*, Schauer) and the Morrel; it seemed to him to have the timber of the York Gum and the twigs of the Morrel.

I have not been able to obtain twigs of any of Mr. Brockman's or of Mr. Johnston's supposed hybrids, so I cannot express an opinion as to their botanical relationships, but I think it is highly probable that hybridism does explain the puzzling variations to be referred to in regard to the Morrels.

In Journ. W.A. Nat. Hist. Soc., III, 168, (1911) I identified a specimen of var. *gracilis* from near Salt River, ten miles east of County Peak, Beverley, W.A., as the "Parker Gum" of the *new* settlers, "but not to be confused with

[1] "Western Mail," (Perth), 15th January, 1910.

the true "Parker Gum" allied to or identical with the Morrel" *(E. oleosa* var. *longicornis).*

So here we have, from two sources, var. *gracilis* known as "Morrel." We also know that the true "Morrel" is *E. oleosa*, F.v.M. var. *longicornis*, F.v.M. The two trees are also known colloquially as "Parker Gum." The bushman recognises the affinity of *E. calycogona*, Turcz. var. *gracilis*, Maiden and *E. oleosa*, F.v.M. var. *longicornis*, F.v.M. and botanically there is no doubt that the species *E. calycogona* and *E. oleosa* are closely related.

Additional localities are:—

Sandhills east of Ooldea, S.A. Transcontinental Railway Survey. A graceful Mallee of about twenty feet, "Congel" of the blacks, who eat the bark of the root. A dwarf, comparatively sturdy Mallee, Streaky Bay, S.A.—(Henry Deane.)

It is not common in New South Wales, having been recorded hitherto from such dry areas as Mount Hope (on the Euabalong road) and Wentworth. We want to be able to define its New South Wales range better.

A Queensland form.—I now desire to invite attention to a form first received from Mr. Ivie Murchie from Normanton, Queensland, not far from the Gulf of Carpentaria, in November, 1911, under the name of "Box Wood."

Enquiries failed to elicit any further particulars until Mr. R. H. Cambage collected it at the same place in August, 1913. He obtained a full suite of specimens and furnished the following particulars:—"No. 3930. Small Box-trees of ten to thirty feet, sometimes suggestive of Mallee. Leaves bright green, somewhat shiny, give *no* odour of oil when crushed. Box-bark on trunk and large branches. Upper branches sometimes smooth and greenish.

"Formation pebbly (ironstone) and sandy; Cretaceous?

"Also occurs on Normanton-Cloncurry road between Normanton and Flinders River."

So far as I am aware, var. *gracilis* has not been recorded previously from nearer than 1500 miles and it is not to be surprised that the Normanton specimens differ a little from the type. I fail to get hold of any characters of sufficient importance to separate it from var. *gracilis*, and therefore note *E. calycogona* var. *gracilis* as an addition to the Queensland flora.

Compared with typical var. *gracilis*, the leaves are of a different texture, and there is a sticky exudation in patches, the result of insect punctures.

Mr. Cambage's note of absence of oil does not mean that there is no oil at all, for the oil dots can be seen and are not scarce, but in comparison with other forms, there is an absence of oil. At the same time the leaves from southern specimens of var. *gracilis* vary a good deal in oil-content. The most important character is that the inflorescence is terminal in the Normanton specimens (chiefly those of Mr. Murchie), whereas it seems to be usually axillary in all our other specimens.

3. E. Cooperiana, F.v.M., Fragm. xi, 83, (1880).

Described without fruit. Mueller *(loc. cit)* said that Bentham had placed it under *E. decurva*, F.v.M. That this is not correct may be seen on reference to Part xvi of my "Critical Revision of the genus Eucalyptus."

At one time I thought it might be included under *E. cladocalyx*, F.v.M., but the peduncles and pedicels of *E. Cooperiana* are broader than those of *E. cladocalyx*, while the anthers are as a rule very different, but those of *E. cladocalyx* are exceptionally variable.

It is nearer to *E. Flocktoniœ*, from which it differs in the broad peduncles and pedicels, the broader leaves and the

operculum, which is long in *E. Flocktoniæ.* At the same time it is a species which requires further investigation.

Although Mueller said he had not seen it in fruit, I have received from Prof. Ewart a small twig bearing two not fully developed fruits, which certainly bear some general resemblance to those of *E. Flocktoniæ.*

4. E. FALCATA, Turcz.

(Syn. *E. Dorrienii*, Domin.)

E. Dorrienii was described by Domin in Fedde's "Repertorium specierum nov. reg. veget." XII, 388 (1913).

The author says in his opinion it is nearest to *E. decurva*, F.v.M., and also compares it with *E. oleosa*, F.v.M., and *E. falcata*, Turcz. In comparing it with the last species, he says "*E. falcata* reminds us of it in the ribbed calyx-tube but differs from it greatly in the operculum."

I am in possession of a quarto drawing of the type in the Kew Herbarium done by Miss M. Smith, and also a fragment of the type. I fail to see in what way *E. Dorrienii* differs from *E. falcata.* The opercula of the two species are precisely similar. See Plate 68, Part xv of my "Critical Revision of the genus Eucalyptus."

The suggestion of the affinity of *E. Dorrienii (falcata)* with *E. decurva* is doubtless founded on the same error that I have pointed out in my "Critical Revision," Part xvi, p. 193.

5. E. KRUSEANA, F.v.M.

(Syn. *E. Morrisoni*, Maiden.)

This was described in the "Australian Journal of Pharmacy" (Melbourne) for August, 1895, p. 233.

I described *E. Morrisoni* in the "Journ. Nat. Hist. and Science Soc. of W.A., Vol. III, p. 44 (1910). I find that the two species are identical, and therefore *E. Morrisoni* must

fall. I endeavoured to see Mueller's type many years ago, but it was detained by Mueller's trustees for a number of years, and was not seen by me until Prof. Ewart showed it to me in August, 1911.

Mueller's locality for the type is given in the description as "Fraser's Range, South Western Australia." The specimen itself bears the inscription "100 miles north of Israelite Bay" and doubtless refers to the same locality. My locality for *E. Morrisoni* is "50 – 150 miles east of Kalgoorlie," Transcontinental Railway Survey, is new, but is in the same general locality as the preceding.

6. E. ODORATA, Behr and Schlecht.

This tree is so imperfectly known as a member of the New South Wales flora, that the following particulars in regard to a tree which I critically examined on the spot will be acceptable.

Fairly large tree, trunk eighteen inches in diameter. Bark black, scaly, hard. Timber excessively hard and interlocked, deep brownish-red in colour, certainly with a shade of red in it. Foliage dull; juvenile leaves narrow. Buds clavate and somewhat angular, fruits small, shiny, hemispherical-cylindroid, tips of valves well sunk, peduncles long, pedicels short.

Not well known in the district, and hence called "Bastard Box," a term often applied by bushmen to a tree they do not well know, and not necessarily suggestive of hybridism.

Girilambone, 410 miles west of Sydney, on the Travelling Stock Route from Railway Station in direction of the Mine, half a mile from the Station.

The above tree a friend tested with an axe, and timber and bark and complete set of specimens were obtained. It is the type form of *E. odorata*, nearest to that described as *E. cajuputea*, F.v.M. (Crit. Rev., Part xi, p. 27) in con-

tradistinction to var. *calcicultrix*, Miq. (*op. cit.*, p. 28), which favours limestone areas. This specimen shows that the typical form obtains great development in New South Wales.

Although I did not preserve the timber, and the particular trees were somewhat smaller, the following specimens are referable to the same species.

"Mallee Box" (the local name) twelve to fourteen inches diameter. Peppermint-scaly bark up to branches. A very tough, hard wood. Fruits variable in size, some very small. From Coolabah Station, four and a half miles on the road to the late Coolabah Experiment Farm.

7. E. PAPUANA, F.v.M., Mueller's Papuan Plants, I, 8 (1875).

(Syn. *E. clavigera*, A. Cunn. var. *Dallachiana*, Maiden.)

In the Journal of this Society, XLVII, 76 (1913), I drew attention to a Queensland tree which, in my opinion had been erroneously looked upon as a variety *(Dallachiana)* of *E. tesselaris*, F.v.M. I suggested that it is a form of *E. clavigera*, A. Cunn., and I still am of opinion that it is closer to that variable species than to *E. tesselaris*.

But for some time past I have held the opinion that it might be worthy of specific rank, and Mr. R. H. Cambage, who the year before last botanised in Northern Queensland, independently came to the same conclusion, stating that, in his opinion, it is sufficiently distinct from *E. clavigera*.

E. papuana was described by Mueller from complete herbarium material, but the specimens have disappeared from the Melbourne Herbarium, with the exception of some leaves, one of which has been presented by Prof. Ewart to me. Careful study of the description, and examination of the leaf, leaves very little doubt in my mind that it is identical with my *E. clavigera* var. *Dallachiana*.

The line of demarcation, at least as regards leaves, between *E. clavigera* and *E. clavigera Dallachiana* (*E. papuana*) is, however, not sharp, particularly as regards Melville Island and Papuan specimens. I will bring this out in my "Critical Revision," as illustrations are necessary.

E. papuana came from the mainland of New Guinea (Papua), opposite Yule Island, and about twelve miles distant from the shore.

8. E. SEEANA, Maiden, Proc. Linn. Soc. N.S.W., XXIX, 469, (1904).

Following are additional localities for a species at one time deemed to be rare:—

Port Macquarie to Telegraph Point, near the seven-mile post from the former place. In poor ill-drained land. (R. H. Cambage and J.H.M.)

Tree three feet in diameter and fifty feet high, larger than I have previously seen it. With pedicels thicker than in the type. The prevalent colour of the foliage is dull, and it is somewhat rich in oil. We found numbers of very narrow-leaved seedlings.

There is some general similarity in the appearance of the seedlings of *E. Seeana* and *E. squamosa*, Deane and Maiden, but the cotyledon leaves are bilobed in the former case, and bisected in the latter.

"Cabbage Gum," Tooloom. Occurring at various points between Drake and Tabulam. Good for posts but bad for splitting or sawing. Withstands bush fires, which run round it and only blacken it." (R. H. Cambage, No. 2898.)

GEOLOGY OF THE JENOLAN CAVES DISTRICT.

By C. A. SÜSSMILCH, F.G.S., and W. G. STONE.

With Plates LV, LVI.

[*Read before the Royal Society of N. S. Wales, December 1, 1915.*]

Part I. General Geology.

By C. A. SUSSMILCH.

A. Introduction.

The field work upon which this investigation is based was started some ten years ago for the purpose of providing practical field instruction for the students of the geology classes of the Sydney Technical College. On each subsequent annual visit a few days have been spent in continuing the work, but as the time available was always short, and as much attention had to be given on each visit to the demonstration of ordinary geological principles, the work has necessarily been slow and limited to that part of the district immediately adjoining the Caves.

The Jenolan Caves form such an important tourist centre and are visited by so many who are interested in geology, that it will no doubt serve a useful purpose if the information thus gathered together be now placed on record.

The Jenolan Caves occur in the Parish of Jenolan, in the County of Westmoreland, N.S.W., and are situated on the Jenolan River a short distance from its source on the eastern fall of the Main Divide. They are about thirty-six miles from Mount Victoria, which is the railway station from which visitors usually journey to the Caves, and from which there is a splendid motor road.

The scope of the present paper is limited to a description of the geology and petrology of the country immediately adjoining the Jenolan Caves, but in order to completely solve some of the geological problems of this region, a detailed examination of a much more extensive area would be necessary, than we have had time or opportunity to carry out.

B. Previous Observers.

In 1892 Mr. R. Etheridge, Jr.,[1] recorded the occurrence of *Pentamerus Knightii* and other fossils in the Jenolan limestone, and expressed the opinion that the geological age approximated to the Aymesbury Limestone of England. In 1896 Prof. T. W. E. David[2] in a paper on "Radiolaria in Palaeozoic Rocks," gave a brief description of the geological features of the Jenolan Cave District with particular reference to the occurrence of the radiolarian cherts.

In 1911, one of us (C. A. Sussmilch)[3] contributed a preliminary note on the geology of the Jenolan Caves District

[1] Records Geological Survey, N.S. Wales, Vol. III, part ii, 1892, p. 57.

[2] The occurrence of Radiolaria in Palaeozoic Rocks in N.S. Wales by Prof. T. W. E. David, B.A., F.G.S., Proc. Linn. Soc. N.S.W., 1896, Vol. XXI, pt. iv, p. 553.

[3] Note on the Geology of Jenolan by C. A. Sussmilch, F.G.S., Austr. Assoc. Adv. Sci., 1911, p. 120.

to The Australasian Association for the Advancement of Science. This was published in abstract only. In 1913 the same writer[1] gave a brief abstract of the geology of the Jenolan District in his Introduction to the Geology of New South Wales.

C. Physiography.

The Jenolan Caves occur in one of the valleys of the western part of the Blue Mountain Tableland. A general description of the physiography of this tableland has already been published by the writer,[2] and a more detailed description is in course of preparation, so that only a brief account is necessary here.

That part of the Blue Mountain Tableland in which the Jenolan Caves occur has an altitude of from 3750 to 4000 feet, and its surface is a peneplain cut out of highly inclined Palaeozoic strata and their associated igneous intrusives. This peneplain is of Tertiary age and was elevated to its present position at the close of the Tertiary Period (Kosciusko Epoch). Rising above the general level of this peneplain are residuals of the older tableland out of which it has been cut; Mount Bindo is an example and is 4460 feet in altitude.

Since the uplift of the tableland it has been deeply dissected by stream action, and is now traversed by a series of deep gorges; it is in one of these gorges, that of the Jenolan River, that the Jenolan Caves occur. In the Blue Mountain Tableland as a whole, the present cycle of erosion has reached early maturity, but in the Jenolan Cave District, which is close to the Main Divide, the valleys are still in the youthful stage of their development and are

[1] An Introduction to the Geology of New South Wales, by C. A. Sussmilch. Government Printer, Sydney, 1913, and 2nd Edition, Angus and Robertson, 1914.

[2] Handbook for the New South Wales Meeting of the British Association for the Advancement of Science, Sydney, 1914. The Central Tableland of N.S. Wales, by C. A. Süssmilch, p. 495, (1914).

typical V-shaped gorges with steep grades, steep walls and narrow bases. So steep are the valley walls that landslips are frequent. The whole region is very rugged and difficult of access, and geological field-work, except along the few roads and pathways, is both difficult and arduous.

The limestone caves occur where the Jenolan River and its tributary McEwens Creek, have cut their channels across a thick bed of limestone (the Cave limestone), the various cave levels representing successive levels of the streams' channels as they cut their way downwards from the tableland surface. Owing to the extent to which the limestone resists mechanical erosion as compared with the slates and cherts which lie on either side of it, it now stands as a great wall across the course of the stream from one side of the valley to the other, and entirely cutting off the head of the valley from that part below. The drainage from the upper valley passes through this wall by means of natural tunnels carved out of the limestone by chemical action, such as the Grand Arch and the Devil's Coach-house. This limestone wall, at its lowest part, rises 300 feet above the present stream channel. The Cave House is in the upper valley and the road to it from Mount Victoria passes through the Grand Arch (see Pl. LV). This great wall of limestone is a most impressive feature, particularly when viewed along the direction of its strike, and from a position where one can see how completely the upper valley is cut off from the lower valley by it.

In their geological features the Jenolan Caves do not differ from other limestone caves, and for a detailed description of them the reader is referred to the excellent guide-book written by Mr. O. Trickett, L.S., and published by the Department of Mines. Each of the cave-levels marks the one time channel of the Jenolan River or one of its tributaries, and all of them contain deposits of river-

gravel, some of the pebbles of which reach a foot or more in diameter; the rivers themselves still flow through the lowest cave-levels.

A word might be said here about the probable age of the Caves; observations have been made of the present rate of growth of some of the stalactites and stalagmites in the caves, and assuming that the rate of growth so obtained to have been the same ever sinoe the caves first began to form, estimates of many million years have been made as to the age even of some of the stalactites. It is obvious that the Jenolan Caves could not have been formed before the valley in which they occur was formed, and this cannot date back beyond the end of the Tertiary Period, when the tableland was uplifted to its present height. The most liberal estimates of the length of time which has elapsed since the end of the Tertiary Period do not exceed 1,000,000 years, while many estimates do not exceed 500,000 years. The present caves occur more than 1000 feet below the tableland level, so their age must be considerably less than that of the valley as a whole; it is therefore quite improbable that the age, even of the oldest of the caves can exceed 500,000 years.

D. General Geology.

The various rock formations met with in travelling from Mount Victoria to the Jenolan Caves may be classified, according to geological age, as follows:—

Mesozoic	Triassic	Hawkesbury Series.
Palaeozoic	Permo-Carboniferous	Upper Coal Measures. Upper Marine Series.
	Upper Devonian	Granites, quartz porphyrites, felsites, Mount Lambie Beds, quartzites, etc.
	Silurian	Jenolan Series—Slates, quartzites, limestones and rhyolite lavas.
	(?) Ordovician—Jenolan radiolarian cherts.	

The Triassic and Permo-Carboniferous strata do not occur within the area dealt with here and will not be further referred to; this applies also to the Mount Lambie Series of Upper Devonian age. The sedimentary formations actually occurring in proximity to the caves are of (?) Ordovician and Silurian age, and these are intruded by igneous rocks of late Devonian age.

(*a*) The (?) Ordovician Strata.

The Radiolarian Cherts.—These lie to the west of the Cave limestone, and are well shown in the cuttings along the Tarana Road in the immediate neighbourhood of the Cave House. They vary from jet black to bluish-grey in colour, are exceedingly compact and fine-grained, and rarely exhibit stratification; when the latter is visible it is marked by a series of alternating thin layers of lighter and darker material.

Prof. T. W. E. David has already described these beds as follows:—

"Immediately overlying the limestone are fine-grained dark clay-shales and argillites and black cherts. Mr. V. Wyburd, the guide to the Caves, informs me that these must be at least 1000 feet in thickness. The dark shales are not distinctly cherty except where they are in close proximity to the eruptive dykes. The cherty character of the beds in this case is due therefore, I think, to contact metamorphism rather than to silica derived from radiolarian shells. Both the black cherts and the softer and less siliceous dark grey shales abound in casts of radiolaria. The casts are in the best state of preservation in the cherty bands."

No attempt has been made on our part to determine the actual thickness of these beds, but they are unquestionably very thick, probably considerably more so than the 1000 feet mentioned above. We are also of opinion that their cherty nature is independent of their contact with the igneous dykes as they possess this character at distances

too far away to have been effected by them. One sample taken from locality A on the map (Plate LV) yielded on analysis 70·1% of silica. These cherts and dark claystones are so poorly stratified and are so crowded with joints that it is difficult, except in a few places, to determine their true dip and strike. Until quite recently it had always been supposed that they were conformable with the Cave limestone and geologically above it, and that they, therefore, were a part of the Silurian series. A more careful field study made by us this year resulted in finding a number of places where the dip and strike departed widely from that of the Cave limestone. The observed strikes range from N. 10° W. to N. 45° E., the positions of some of these are shown on the accompanying geological map. The strike of the Cave limestone is about N. 20° W., while its dip is westerly at from 60° to 65°. In some places, notably at A on the map, the strike of the cherts parallels that of the limestone, but the dip is easterly at a high angle, that is towards the limestone, and in the opposite direction to the dip of the latter. The general strike of the radiolarian cherts appears to be about N. 45° E., while the dip is typically a very high angle, in many places almost vertical.

These facts strongly suggest that an unconformity exists between the radiolarian cherts and the Silurian limestone, and if this be so, then their relative positions suggest that they have been brought together by overthrust faulting. If these conclusions are correct then the overthrust parallels the main axis of folding of the Silurian strata (N. 20° W.) and the tangential thrust which produced it must have come from the west.

The probability of such an unconformity receives support from another feature. The radiolarian cherts are intruded by a large dyke of andesite; this intrusion is adjacent to the contact of the cherts and limestones. If the radiolarian

cherts were lying conformably above the limestones, the intrusive andesites would probably have broken through the downward continuation of the limestone in order to reach its present position in the cherts. No evidence has yet been found that the andesite is intrusive into the limestone, and no inclusions of limestone have yet been found in it, whereas inclusions of chert fragments are common. The quartz-porphyrite intrusions lying to the east of the Cave limestone, on the other hand, contain abundant included fragments of limestone, even at considerable distances from the contacts. These facts are difficult of explanation except on the supposition that both cherts and andesites are older than the limestone and have been faulted against it.

There is still one other factor which has a bearing on this problem. At the eastern leg of the Jenolan anticline (see section), the limestone is overlain by a thick series of argillaceous quartzites, these are at least 1000 feet in thickness. These quartzites therefore occupy the same horizon in the eastern leg of the anticline that the radiolarian cherts would in the western leg if the latter were conformable with the limestone. It is difficult to imagine conditions such as that at two places so near to one another there should be a simultaneous deposition of radiolarian cherts and quartzites, the one a relatively deep-water deposit and the other a shallow-water deposit, particularly in view of the great thickness of both deposits.

If the black radiolarian cherts are older than the Silurian limestones, what then is their actual geological age? Lithologically they much resemble the Ordovician strata from such localities as Cadia, Tallong and Berridale; further, the occurrence of radiolaria in Ordovician strata is common in New South Wales, although it must not be forgotten that radiolaria have been identified by Prof. David in the slates

underlying the Cave limestone and which are of Silurian age, although he referred to these as being doubtful. It would appear probable therefore that these Jenolan radiolarian cherts are of Ordovician age. While it cannot yet be said to have been definitely proved, the balance of evidence at present available strongly suggests therefore, that (*a*) the radiolarian cherts of Jenolan are unconformable with and older than the Silurian strata and (*b*) that they are probably of Ordovician age.

(*b*) The Silurian Strata.

These include limestones, slates, and quartzites, with what is probably a contemporaneous rhyolite lava flow. The succession of strata in descending order is as follows:—

Argillaceous quartzites and slates	1000′ + (actual thickness unknown.)
Slates	100′
Limestones	550′
Slates	100′
Rhyolite lava flow	300′
Slates	1000′ + (actual thickness unknown.)

These strata have a general strike of about N. 15° W. to N. 20° W., and in the district mapped form part of a great anticline. This anticline is a symmetrical one, the eastern and western legs both dipping at an angle of about 60°. Extensive intrusions of quartz-porphyrite have taken place along the axis of the anticlines, particularly in the slates below the limestone, and near the contact of these intrusives some local irregularities of dip occur in the slate.

1. *The Limestones.*—Two belts of limestone occur in the region examined, (*a*) the one in which the Jenolan Caves occur, and (*b*) the limestone which outcrops to the east in the banks of Jenolan River about two miles below the Grand Arch. The former will for convenience be referred to as the Cave limestone, the latter as the eastern limestone belt.

The Cave limestone is about 550 feet thick, strikes N. 20° W. and extends north with an unbroken outcrop for three miles and southwards for upwards of two miles. It is bluish-grey to blue-black in colour and is very massive in character and almost devoid of bedding planes; near the top of the bed however, some interstratification with shales takes place and the bedding planes thus become marked.

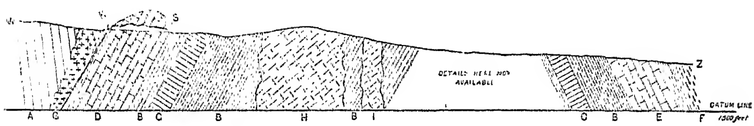

Fig. 1.—*Sketch Section of Strata, Jenolan District,* on line W Z on map. (Plate LV). Vertical Scale 1 inch = 2500 feet. Horizontal Scale 1 inch = 2000 feet.

A Radiolarian cherts (? Ordovician), B Silurian slates; C Rhyolite porphyry (? Lava Flow); D Cave limestone; E Eastern limestone belt; F Quartzites; G Intrusive andesite; H Quartz-porphyrite (pink variety); I Quartz-porphyrite (green variety); K Probable overthrust fault; S Grand Arch.

This may be seen on the Tarana road, at the place marked B on the map, just above the Cave House; the dip here is to the west at about 60°. Jointing is, however, strongly developed, there being in general two main sets, approximately at right angles to one another; these are well shown in the Devil's Coach House and at the eastern entrance to the Grand Arch. In the Lucas Cave large masses of limestone have broken away from the roof of the cave and here the joints are particularly well shown.

Visible fossils are not frequent except in a few localities the best being the road-cutting on the Tarana Road about a quarter of a mile from the Cave House, just at the sharp bend behind the Engineer's cottage at the place marked C on the map. The following is a list of those fossils so far identified from this district:—

Hydrozoa ...*Stromatopora*
Actinozoa ...*Favosites gothlandica, Heliolites porosa*
Crinoidea ...Stems and ossicles

Brachiopda ...*Pentamerus (Conchidium) Knightii*
Gasteropoda...*Palaeoniso Brazieri*, *Loxonema antiqua* (?) *Velotuba*
Cephalopoda...*Orthoceras*, *Lituites*
Trelobita ...*Sphaerexochus mirus*, (?) *Phacops*.

These have been determined by Messrs. R. Etheridge, Jr. and W. S. Dun. Of these fossils Pentamerus, Favosites, and Stromatopora are the most abundant.

The eastern bed of limestone, as already pointed out, lies to the east of the cave limestone, and strikes about N. 20° west, but it dips to the east at an angle of about 65°. It is not so massive as the Cave limestone and is more definitely stratified, there being frequent intercalation of beds of shale. No fossils have yet been obtained from this bed.

The relative position of these two limestone beds with regard to one another and to the associated strata, indicate that they are part of one and the same bed, the Cave limestone occurring in the western leg of a great anticline, the other occurring in the eastern leg of the same anticline.

On top of the ridge formed by the Cave limestone, remarkable examples of the "rills" or grooves formed by the chemical action of rain-water upon the surface of the limestone outcrops may be seen; some of these simulate in a remarkable way the drainage system of a steep mountain range; these are particularly well shown on the top of the Lucas Rocks, and above the Carlotta Arch.

2. *The Slates.*—These are typical examples of the so-called Silurian slates of New South Wales, and are well shown in the road-cutting on the Mount Victoria Road for the last four miles before reaching the Caves. In colour they may be light-grey, bluish-grey, red, or dark-green; they are much jointed and usually break more readily along the joint planes than along the laminations, but do not possess the fissile structure of a typical roofing slate. The

fracture displays a lustrous surface due to the presence of minute mineral particles which have resulted from regional metamorphism. They are for the most part thinly bedded, but some massive strata also occur. Professor David has referred to the occurrence of doubtful *Radiolaria* in some of these slates, but otherwise they are unfossiliferous. This question of the occurrence of *Radiolaria* has not been further investigated by us.

Quite apart from the small amount of contact metamorphism shown at their junction with the intrusive igneous rocks to be referred to later, they exhibit a varying amount of regional metamorphism which has resulted in the development of minute crystals of secondary minerals. These are too small to be seen in hand specimens, but their presence is indicated by the lustrous surfaces given when the rock is split. Denudation has not cut deep enough into the Jenolan anticline to reveal the true thickness of these slates, and owing to the extent to which they have been intruded by later igneous rocks, it is difficult to determine the thickness of that portion exposed, but it must be at least 2000 feet. Excellent exposures of these slates can be seen along the cuttings of the Mount Victoria-Jenolan Road, quite close to the Grand Arch.

The association of limestone and slates at Jenolan, and the particularly favourable conditions for quarrying them, would give ideal conditions for the manufacture of Portland cement, were it not for the great difficulty of access, owing to the very rugged nature of the country between here and the nearest railway-line.

3. *The Quartzites.*—These are almost pure white in colour, are very fine-grained and more or less argillaceous; they are also thinly-bedded and much jointed. They outcrop extensively along the bed of Jenolan River immediately to the east of the eastern bed of limestone, where they lie

geologically above the limestones, but separated from them by a thickness of about 100 feet of slates. No fossils have yet been found in these beds, although very little search has yet been made for them.

4. *The Jenolan Rhyolite-porphyry.*—This occurs almost immediately to the east of the Cave limestone, being separated from it by a thickness of 100 feet of slates only. Its bold massive outcrop may be seen crossing the valley just below the Grand Arch, where it forms a very prominent feature. It has the same direction of strike as the Cave limestone and appears to have a similar dip. Mr. V. Wyburd informs me that this outcrop may be traced for many miles in a southerly direction, always occupying a position parallel to and east of the Cave limestone.

In the hand specimen, this rock has all the characters of a typical intrusive quartz-porphyry; it is almost white in colour, and is usually markedly porphyritic, containing large phenocrysts of quartz and felspar set in an aphanitic groundmass. It resists weathering, giving bold rugged outcrops, and so resistant is it to the forces of denudation that the valley of Jenolan Creek narrows markedly where it crosses the outcrop of this rock at the "bathing-pool" just below the engine-house. In the valley of McEwans Creek about a mile north of the Grand Arch at a place marked D on the map. This rock is not porphyritic and exhibits a well developed flow structure; the width of outcrop here is much narrower than where it is crossed by Jenolan Creek.

At first sight it seemed probable that this quartz-porphyry was an intrusive rock, but its occurrence in the field and its characters as revealed under the microscope suggest that it is more probably a contemporaneous lava-flow. There are a number of undoubtedly intrusive igneous rocks in the immediate neighbourhood, some of which bear a con-

siderable resemblance to this rock in the hand specimen, but they differ from it considerably in their chemical and petrological character. In the case of these latter rocks, (porphyrites and felsites), there can be no doubt of their intrusive nature; numerous veins run out from them into the adjoining slates, while abundant fragments of the slate occur embedded in the igneous rock at their contacts. No such evidence has been found in the case of the rhyolite-porphyry, although it is true that the contacts so far observed are obscure. In the case of the porphyrites and felsites, the slates have been so much hardened and indurated at their contacts, that weathering has been resisted and good sections of these contacts are given in the road cuttings, whereas in the case of the rhyolite porphyry the slates at the contact have weathered so readily that the actual junction cannot be seen. Along the hill sides and stream channels innumerable boulders of porphyrite with included fragments of indurated slate may be seen; but no boulders of the rhyolite porphyry with such inclusions have yet been found.

The chemical composition of the rhyolite porphyry in comparison with that of the other igneous rocks of the district is given in Part II; it will be seen that it differs from the intrusive quartz porphyrites and felsites in (*a*) being more acidic, (*b*) in the proportion of the alkalis present, potash preponderating over soda, whereas in the other rocks the reverse is the case.

If the rhyolite-porphyry be a contemporaneous lava flow, it would of necessity have been subjected to the same folding forces as the Silurian sediments, and one might expect a repetition of its outcrop in the eastern leg of the anticline; this repetition does occur in the actual position one might expect to find it, as shown in the geological section. Specimens from this occurrence have such similar

lithological and petrological characters to those of the rhyolite-porphyry near the Grand Arch that there can be no doubt that they have been derived from one and the same magma. The outcrops of this second occurrence along the line of section are such, however, that their stratigraphical relations with the adjoining slates are not clear, and neither time nor opportunity have allowed of our investigating this matter further at this locality.

It might also be expected that if this rock were a contemporaneous lava flow which had been subjected to the same folding as the Silurian sediments, that it would show some evidence of metamorphism, and this is actually the case. Micro-slides show that the rock has been subjected to considerable pressure; many of the biotite crystals are bent; the quartz crystals are shattered and fractured; and in some slides the rock shows distinct foliation, with the development of sericite and secondary quartz. These features are not shown by any of the undoubtedly intrusive rocks.

Much more field work would be necessary to settle the intrusive or effusive origin of this rock beyond doubt, but the balance of evidence at present available seems to be in favour of the latter view. The occurrence of rhyolite lava-flows of Silurian age is not uncommon, as they have been recorded for the Orange District,[1] the Yass District,[2] and the Canbelego District.[3]

(c) The Igneous Intrusions.

Not the least interesting feature of the geology of this region is the number and variety of the intrusive igneous

[1] The Silurian and Devonian Rocks of the Orange District, by C. A. Sussmilch, this Journal, Vol. xl, page 130.

[2] The Geology of the Yass District by A. J. Shearsby, Report of the Thirteenth Meeting of the Australasian Association for the Advancement of Science, Sydney, 1911, p. 106.

[3] The Canbelego Budgery and Budgerygar Mines by E. C. Andrews, B.A. Mineral Resources, No. 18, Department of Mines, N. S. Wales, 1915.

rocks; these include the following:—1. The Andesites, 2. The Quartz-Porphyrites, 3. The Felsites, 4. The Diorites. The andesites are limited in their occurrence to the region lying to the west of the Cave Limestone and intrude the radiolarian cherts only; all the other intrusions occur to the east of the Cave Limestone and intrude the Silurian strata.

1. *The Andesite.*—This occurs in the form of a dyke striking nearly north and south, and, as may be seen from the geological map, parallel to and very close to the junction of the radiolarian cherts and limestones. Good exposures have been found at two localities only, viz., (1) immediately adjoining the Cave House, and (2) some distance up McEwans Creek at the place marked A on the geological map. At the former locality this rock was extensively exposed by the quarrying done in making the foundations for the Cave House. The dyke here is upwards of 150 feet in thickness and careful examination shows it to contain two distinct rock types, one in which there are abundant black phenocrysts, the other in which such phenocrysts are absent; the former will be referred to as the porphyritic type and is a hornblende-augite-andesite, the latter will be referred to as the non-porphyritic type and is an augite-andesite.

The augite-andesite is an aphanitic rock, greenish-grey in colour and is much jointed; many of these joints are slicken-sided and contain films of calcite, chlorite, etc. It is traversed in places by very thin veins of quartz, some of which contain a little arsenopyrite; this latter mineral and pyrite also occur as occasional minute crystals sporadically scattered through the rock. This non-porphyritic type of andesite occupies by far the larger part of the intrusion. The porphyritic hornblende-augite-andesite contains abundant black phenocrysts of augite and horn-

blende; the relative proportion of these two minerals is very variable, in some specimens the augite preponderates to the exclusion of the hornblende, while in other specimens the reverse is the case. This type occurs as more or less rounded inclusions in the non-porphyritic type, and very irregularly distributed through it; the inclusions themselves are very variable in size ranging from an inch up to several feet in diameter. The junctions between the two types are always quite sharp.

This rock weathers very readily and gives few good outcrops, and little would therefore have been known of it, had it not been cut away in making the foundations for the Cave House, and in making road cuttings. These operations have not exposed either wall of the dyke.

At the other good outcrop mentioned (the place marked A on the map) instead of one large dyke, there are two small dykes, which are exposed in the face of a waterfall in the channel of one of the tributaries of McEwan's Creek. One of these dykes contains the non-porphyritic type of andesite only, and is ten feet thick, the other contains the porphyritic type only and is fifteen feet thick, (see Fig. 2).

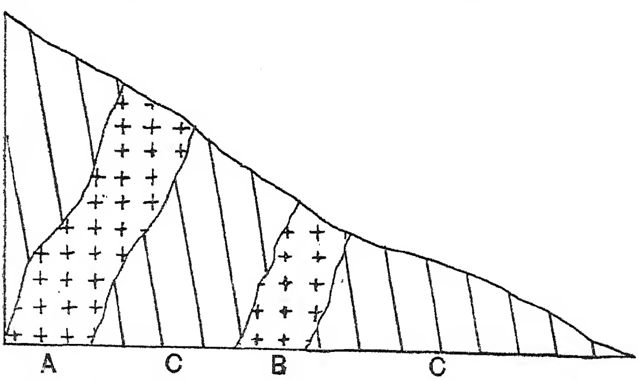

Fig. 2—Sketch Section at A on Map (Plate LV) showing andesite dykes intruding radiolarian cherts. A—Andesite-porphyritic type. B—Andesite-non-porphyritic type. C—Radiolarian cherts.

The porphyritic type from this locality contains biotite in addition to augite, and has a decidedly lamprophyric structure and could be called a true lamprophyre.

We have been unable to find outcrops between the two localities already referred to, although fragments have been found in one or two places near the Tarana Road in the surface soil along the line of strike; there is, however, little doubt that they form part of a continuous intrusion, the absence of good outcrops being due to the ready decomposition of the rock.

At first it was thought that the patches of porphyritic andesite occurring in the non-porphyritic andesite were xenoliths, but the occurrence of the two rock types in two separate dykes at locality A, suggests that the occurrence at the Cave House is a composite dyke in which there was first intruded the porphyritic type of andesite, to be followed later by the non-porphyritic type, the later intrusion breaking up and partly reabsorbing the already consolidated earlier intrusion. At the more northerly locality (A) the combined bulk of the two intrusions is much smaller, and the second intrusion did not keep to the same channel as the earlier one, and thus formed a separate dyke. A detailed petrological description of these andesites with analyses is given in Part II, and it will be seen that they are sufficiently alike to have originated from a common magma.

The age of this intrusion is difficult to determine; it intrudes the radiolarian cherts and is therefore newer than them, but is not known to intrude the Silurian strata. It is practically in contact with the Cave limestone just south of the Cave House, yet no included fragments of limestone have yet been found, whereas included fragments of the radiolarian cherts are common. Included fragments of limestone are quite common in the quartz-porphyrites and

felsites east of the Cave limestone, even at points distant from the junction. These facts have already been referred to in discussing the age of the radiolarian cherts, and it is quite possible that it was faulted against the limestone along with the cherts, in which case it would be older than the other igneous intrusions, which are of late Devonian age. On the other hand its strike approximates to that of the more acid intrusives occurring to the east of the Cave limestone, and it could possibly, therefore, have resulted from the same set of activities. In its petrological characters, this rock much resembles the intermediate intrusive and effusive rocks associated with the Ordovician rocks of the Orange District. Until more information is available it is impossible to assign any definite age to this intrusion, but there is some reason for thinking that it may be older than the late Devonian (Kanimbla Epoch) intrusives, and that it may even be Pre-Silurian in age.

2. *The Quartz Porphyrites.*—These occur to the east of the Cave limestone and intrude the underlying slates; that they also intrude limestone is shown by the large number of included limestone fragments which they contain, but no actual intrusion into limestone was observed in the area mapped. Two distinct types of porphyrite occur, one of these has a reddish colour and will be referred to, for the sake of convenience, as the Pink Porphyrite; the other has a decidedly greenish colour and will be referred to as the Green Porphyrite. They are sufficiently alike in their chemical and petrological character to be both classified as quartz-porphyrites, but there are also differences both chemical and petrological which will be referred to in Part II.

The pink porphyrite is a reddish aphanitic rock, typically with but few phenocrysts of quartz; in places, however, there is a considerable development of small phenocrysts

of red felspar and quartz, notably on the track down Jenolan Creek at the place marked E on the map. The contact of this rock with the Silurian slates which it intrudes is well shown in the road cuttings on the Mount Victoria road (at G on the map). Here numerous tongues of the igneous rock may be seen running out into the slate, while numerous fragments of the slates may be seen entirely surrounded by the porphyrite, the whole giving the appearance, at first sight of a coarse volcanic breccia; the mixed rock in this marginal zone may be referred to as a contact breccia. The included fragments of slate have, for the most part, been well rounded by corrosion, and the slate has been indurated and hardened into a porcellanite or lydian stone.

The green porphyrite, as the name implies, has a greenish colour, particularly when slightly weathered, the colour being due to the presence of secondary chlorite. This rock is usually crowded with small phenocrysts of quartz and felspar, and when weathered looks not unlike a coarse sandstone. Similar intrusive contacts occur to those described in connection with the red porphyrite.

Both of these rocks are traversed by numerous irregular but closely set joints, and when weathering break up into small angular blocks. They both occur as large irregular dykes conforming in general direction to the strike of the Silurian slate, although not entirely so. They are related in composition to the tonalites which occur in the great bathylith of the Kanimbla Valley. This bathylith, which contains granites, tonalites as quartz-augite-diorites, extends along the valley of Oaky Creek to within a few miles of the Jenolan Caves, and these quartz porphyrites are probably apophyses of this bathylith. It will be noticed on referring to the geological map that the intrusion of pink porphyrite is separated from a neighbouring intrusion of green porphyrite by a long narrow belt of slates; it would

seem hardly probable, under the circumstances, that the two were intruded simultaneously; one would expect the belt of slates to have been broken up and shattered under such conditions. So that it seems probable that one of these rocks was intruded later than the other; as to which was the later there is at present no evidence to show; it is not considered, however, that any great period of time elapsed between the two intrusions, but that they both belong to the one epoch.

The Kanimbla Valley bathylith intrudes Upper Devonian as well as Silurian strata, and the writer[1] has previously assigned a late Devonian age to it (Kanimbla Epoch). The quartz porphyrites are probably of the same age.

The contacts of the intrusions with the rocks they intrude are very interesting from the point of view of the methods by which the intrusion took place. That there has been some marginal assimilation there can be no doubt, but this has been relatively small in amount and has not produced any marked difference in that part of the porphyrite in contact with the slate, as compared with that some distance away. The features of the contact strongly suggest mechanical methods of intrusion, such as the theory of "overhand stoping" suggested by Reginald Daly. Large blocks of slate, many feet in diameter, can be seen already "undercut" and apparently just ready to break away; other large masses of slate twenty to fifty feet, or even more, in diameter, occur entirely surrounded by igneous rock. Such masses have frequently broken away along the bedding planes leaving the igneous rock in places with a contact like that of a sill. These features are well shown in the road cuttings of the Mount Victoria road.

[1] Introduction to the Geology of New South Wales. Angus and Robertson, Sydney, 1914, p. 80.

3. *The Quartz-Felsites.*—These are more highly acidic in composition and occur in smaller intrusions than the quartz porphyrites. As shown on the map they occur between two large intrusions of green porphyrite, and one of them, at least, appears to be genetically connected with this rock, although this connection is not shown on the map. These felsites are well exposed in the road cuttings at the head of Hinchman's Creek; some are unquestionably intrusive, but one of them, which is only about twelve feet thick, lies conformably between the bedding planes of the slates, just like a contemporaneous flow. This occurs at the point marked H on the map, although the actual occurrence is not shown. An adjoining felsite intrusion is simply crowded with fragments of limestone, which must have been brought from some distance, as there is no limestone occurring in the immediate vicinity. Quite a number of felsite dykes (or ? sills) occur at this locality, but as it would be impossible to show them all on the map, they are represented thereon as two intrusions; they alternate with slates.

4. *The Diorites.*—One outcrop of diorite has been noticed; it occurs on the track leading down Jenolan Creek at the place marked J on the map. The rock is fine-grained, almost aphanitic, and is much altered. It exhibits no features of special interest.

Part II. Petrology and Analyses.

By W. G. Stone.

A. The Rhyolite Porphyry (Quartz-porphyry.

B. The Andesites.
- (*a*) Andesite (non-porphyritic type).
- (*b*) Augite-Hornblende-Andesite (porphyritic type).
- (*c*) Augite-Lamprophyre.

C. The Quartz-Porphyrites.
- (*a*) Granophyric-Quartz-Porphyrite (pink variety).
- (*b*) Quartz-Porphyrite (green variety).

D. The Quartz-Felsites.

In the descriptions of the various rocks, embraced in the area, the subject of the present paper, the writer has endeavoured to give, as far as possible, a general description of each rock type. For this purpose numerous sections of specimens collected from different parts of the same occurrence have been examined. The result is, therefore, more n account of the average rock type, than a detailed description of individual sections. The material taken for analysis was that least likely to be affected by absorptions of the intruded rocks, and therefore, occurring as far as possible from such contacts, and as representative as possible of each occurrence.

In the calculation of the norms all the lime has been included, its combination with CO_2 as calcite etc. not being taken into account, as it is considered that the calcite present would represent in large part, the alteration *in situ* of the lime-bearing minerals. The analyses were undertaken in the Geological Survey Laboratory, through the kind permission of Mr. J. C. H. Mingaye, F.I.C., F.C.S., Analyst in Charge. I wish also to express my indebtedness to Messrs. G. W. Card, A.R.S.M., of the Mines Department, N. S. Wales, and W. N. Benson, B.Sc., B.A., F.G.S., Linnean Macleay Fellow in Geology, for kindly advice.

A. The Rhyolite Porphyry (Quartz-porphyry).

The detailed description given below and the analysis are of specimens taken from the massive outcrop near the Grand Arch. Specimens from other localities will be dealt with more briefly and comparisons made.

Megascopic Description.—Colour is creamy-white with darker blebs due to phenocrysts of quartz. The rock is aphanitic and porphyritic, the phenocrysts present being quartz, felspar, and rarely mica. The quartz is plentiful and represents approximately 10% by volume of the rock; some of the crystals reach 9 mm. in diameter, but the

average is about 3 mm. The felspar phenocrysts, somewhat more plentiful than the quartz, are creamy-white in colour and usually with the dull appearance produced by kaolinization. The crystals range up to 8 mm. in diameter, but average about 2 mm. The mica, which is only sparingly present, is yellowish in colour and averages about 1 mm. in diameter.

MICROSCOPIC DESCRIPTION.—The rock is holocrystalline and porphyritic, with a microcrystalline groundmass. The minerals present are quartz, felspar, biotite and a little apatite. Calcite, chlorite, limonite, magnetite, and possibly ilmenite are present as alteration products.

Quartz.—This is sometimes idiomorphic, but more often shows rounded or irregular outlines due to corrosion, typical examples of which are present. It occasionally encloses crystals of biotite.

Felspar.—This is mainly orthoclase, seldom shows twinning, but exhibits corrosion in some crystals, while others are quite idiomorphic. Some phenocrysts exhibit a microscopic intergrowth with plagioclase (probably albite). Plagioclase crystals are not common. Alteration is present and varies from crystals which are almost fresh to those in an advanced stage of alteration. The secondary products are kaolin, sericite, chlorite and calcite.

Biotite.—This is not plentiful. It is somewhat contorted, has a bleached appearance, is almost colourless and only faintly pleochroic. Iron oxides have separated out as magnetite and limonite along the directions of cleavage, while cloudy patches of calcite are frequent.

Apatite.—This occurs sparingly as minute crystals, both in the felspar and biotite phenocrysts and in the groundmass.

Calcite.—This occurs as an alteration product of the felspar and biotite crystals and also in the groundmass. Its appearance indicates the presence of magnesium carbonate

and probably also of ferrous carbonate. This is borne out by the analysis, which shows that some magnesia and probably some ferrous oxide are combined with the carbon dioxide, there being insufficient lime for that purpose.

Chlorite is a product mainly of the alteration of the felspar phenocrysts. It is pale green in colour and almost isotropic.

The *groundmass* of the rock is microcrystalline and composed essentially of orthoclase felspar and its decomposition products with a little quartz. In places it is much obscured by alteration, mainly the kaolinization of the felspar. The rock is traversed by veins of secondary quartz and much of this mineral occurring in the groundmass is of secondary origin. The groundmass also shows evidence of rather extensive devitrification.

The rhyolite porphyry from the eastern leg of the anticline is seen under the microscope to be identical with that described above. The phenocrysts are in general larger. The felspars show a similar microperthite structure, and are in a more advanced stage of alteration, being in some cases completely altered to a sericitic material, or to a mixture of chlorite, sericite, kaolin, and calcite. The biotite is not so bleached and is consequently more strongly pleochroic. The groundmass is somewhat finer grained, and exhibits a well marked flow structure under the microscope, which may in part, however, be really a foliated structure. The groundmass also shows considerably more alteration, mainly in the formation of sericite-like minerals; these appear to have developed mainly along lines of flow, although in some cases transverse to these directions.

The rhyolite porphyry from this locality also shows evidence of having been subjected to severe dynamic action subsequent to consolidation. The biotite crystals are much

contorted, and the quartz crystals highly shattered, the detached fragments of the same crystal often showing different optical extinction. The felspar crystals also exhibit strain-shadowing and fracturing. What has been referred to in the above description as flow structure may be due in a large part to foliation resulting from dynamic metamorphism, although from the manner in which the groundmass swirls around the phenocrysts as seen in some sections from this part of the occurrence, there can be no doubt that this structure is due in part to the flow of the groundmass before consolidation.

Specimens collected from McEwan's Creek, at the place marked D on the geological map (Plate LV), and which appears to be an undoubted continuation of the occurrence near the Grand Arch, show a well marked flow structure in the hand specimen. This rock under the microscope is seen to be almost coarsely microcrystalline with an allotriomorphic-granular fabric; phenocrysts are typically absent. Veins of secondary quartz are numerous, cutting across the lines of flow. This phase of the rock has the appearance of a rhyolite which has undergone much devitrification, with subsequent intense silicification, the latter generally along lines of original flow. The phase described from near the Grand Arch has more the appearance, both in hand specimens and under the microscope, of a typical quartz-porphyry.

Chemical Composition.

	Per Cent.		Per Cent.
SiO_2	74·18	H_2O (100° C.)	0·15
Al_2O_3 ...	11·15	H_2O (100° C.+)	1·27
Fe_2O_3 ...	0·90	CO_2	2·00
FeO	1·31	TiO_2	0·25
MgO	0·62	ZrO_2	absent
CaO	1·35	P_2O_5	0·15
Na_2O ...	1·00	SO_3	trace*
K_2O	5·86	Cl	trace*

	Per cent.		Per cent.
S (FeS_2) ...	0·01	Li_2O	absent†
Cr_2O_3 ...	absent	V_2O_3... ...	absent
NiO and CoO	absent	CuO	trace*
MnO	0·02		
BaO	0·10		100·32
SrO	present†		

Specific gravity 2·654

* Trace less than 0·01%. † Spectroscopic reaction only.

Norm.

	Per cent.		Per cent.
Quartz ...	41·76	Magnetite ...	1·39
Orthoclase ...	35·03	Ilmenite ...	0·46
Albite ...	8·38	Apatite ...	0·34
Anorthite ...	5·84	H_2O, CO_2 etc.	3·45
Corundum ...	0·92		
Hypersthene...	2·69		100·26

Class I. Persalane Rang 2 Alsbachase
Order 3 Columbare Subrang 2 Mihalose
Magmatic name Mihalose.

B. The Andesites.

In naming these rocks andesites, the writer may appear to be inconsistent, because if adhering strictly to the lines laid down in the description of the quartz-porphyrites of this area, these rocks should also be called porphyrites. These two rock types, however, possess so many points of difference that it would have been confusing, particularly to students, to have called them both porphyrites. The rocks now under consideration, although they are intrusive, have all the appearance, both in hand specimens and under the microscope, of typical andesites, whereas the rocks we are calling quartz-porphyrites are more inclined to a plutonic than to a volcanic type. It is not unusual to call certain dyke rocks andesites, as for example, Harker in his "Petrology for Students," figures and describes a dyke-rock from Northumberland as an augite-andesite.

As already described in Part I, two distinct types of andesite occur, these will be described separately:—

(*a*) Andesite (Non-porphyritic Type).

Megascopic Description.—The colour is dark grey with a tinge of green; phenocrysts are always small and rarely visible to the eye, but on a smooth surface one can, with a pocket lens, see that the rock is crowded with small felspar phenocrysts. Inclusions of black chert are frequently noticed, besides the more abundant inclusions of the porphyritic andesite referred to in Part I.

Microscopic Description.—The rock is holocrystalline and microporphyritic, with a microcrystalline to cryptocrystalline and somewhat turbid groundmass. The phenocrysts are mainly plagioclase with a subordinate amount of augite and hornblende.

Felspar.—The phenocrysts are for the most part small, averaging about 0·4 mm. in diameter, but crystals up to 1 mm. in size occur. These crystals are for the most part rounded or irregular in shape, only occasionally idiomorphic and often encircled by a ring of dark kaolin-like material. These felspars constitute about fifty per cent. of the rock, but are so much altered that any exact determination is impossible. Multiple twinning can be detected in some crystals. The analysis indicates that both orthoclase and plagioclase are present, the latter largely predominating.

Augite.—This is not plentiful. In colour it is pale-green to almost colourless, and is fairly fresh. The crystals vary from 0·25 to 0·50 mm. in size, some few crystals reaching 1 mm. in diameter.

Hornblende.—This is less plentiful than the augite, is yellowish-green in colour and quite fresh. It occurs in typical prismatic and basal sections with strong pleochroism, but the crystals are rather smaller than the augites. Both

the hornblende and augite are remarkably fresh, considering the amount of alteration which the felspar phenocrysts and the groundmass have suffered.

Iron ores.—These are very sparingly present, pyrites being the most abundant; a little magnetite is present.

Groundmass.—This is much altered, and where it admits of any examination it is seen to consist of a microcrystalline to cryptocrystalline base of felted microlites of felspar with some ferro-magnesian mineral, probably augite. A few small patches of calcite were noted.

Chemical Composition (x 63).

	Per cent.		Per cent.
SiO_2	50·05	Cl	trace*
Al_2O_3 ...	19·56	$S(FeS_2)$ ...	trace*
Fe_2O_3 ...	0·90	Cr_2O_3 ...	absent
FeO	6·48	NiO and CoO	trace*
MgO	6·30	MnO	0·09
CaO	5·20	BaO	0·15
Na_2O ...	2·49	SrO	†trace
K_2O	3·09	Li_2O	absent
H_2O (100° C.)	0·43	V_2O_3... ...	0·05
H_2O (100° C. +)	3·90		
CO_3	0·32		99·97
TiO_2	0·55		
ZrO_2	absent	Specific gravity	2·775
P_2O_5... ...	0·38		
SO_3	0·03		

* Trace less than 0·01%.

† Spectroscopic reaction only.

Norm.

	Per cent.		Per cent.
Orthoclase ...	18·35	Magnetite ...	1·39
Albite ...	20·96	Ilmenite ...	1·06
Anorthite ...	23·63	Apatite ...	1·01
Corundum ...	3·47	H_2O, CO_2 etc.	4·65
Hypersthene...	24·00		
Olivine ...	1·45		99·97

Class II. Dosalane. Rang 3 Andase.

Order 5. Germanare. Sub-rang Shoshonose.

Magmatic name Shoshonose.

Although the analysis only gives traces of pyrites the sections certainly show more, this is due to the fact that the material chosen for analysis was carefully selected, any showing pyrites being rejected.

The calculation of the norm also indicates that the bases present are not sufficient to satisfy all the alumina, the balance 3·47 per cent. entering into the norm as corundum.

The microscopic examination shows the rock to be much altered, particularly the felspars, which are now represented largely by a sericite-like material with some kaolin. It illustrates an example of metasomatism, through the action of percolating superficial water acting on the silicate of lime in the felspar, resulting in a loss of lime and a gain in alkalis, particularly potash, and probably alumina, as indicated by the development of sericite and kaolin.

The result of Termiers[1] investigations has shown that in general the above action has resulted invariably in the loss of lime and a gain in alkalis. Silica remains approximately constant, the alumina varies and the magnesia fluctuates between a small loss or gain.

Allotting all the hypersthene molecules together with some of the anorthite to form the augite and hornblende present in the rock, the average plagioclase would be about andesine of a basic character. Plagioclase would also largely predominate over orthoclase. In arriving at the actual mineral constitution from the norm it is also necessary to bear in mind that this rock, particularly the felspar, has undergone a good deal of alteration, which has probably resulted in a loss of lime and a gain in potash and alumina, giving to the norm a higher percentage of orthoclase than actually existed in the unaltered rock.

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[1] Sur l' élimination de la chaux par métasomatose dans les roches éruptives basiques de la région du Pelvoux. P. Termier. Bulletin de la société Géologique de France, series 3, Vol. xxvi, 1898. p. 165.

(b) Augite-Hornblende-Andesite (Porphyritic Type).

This occurs near the Cave House as included fragments and masses of varying size in the compact, non-porphyritic, andesitic dyke previously described. Two phases of this type occur, one characterised by porphyritic augite only, the other by phenocrysts of both hornblende and augite, the hornblende predominating. In all other essentials they are similar, and are undoubtedly cognate, and represent inclusions from the same rock mass. The phase in which augite only occurs, is the one more frequently met with These rocks also outcrop at the locality marked A on the geological map (Plate LV), as described in Part I, but the porphyritic type from here differs so much from that occurring near the Cave House, that it should really be called a lamprophyre, and will be described separately as an augite-lamprophyre.

Megascopic Description.—The augite and hornblende phenocrysts are set in a greenish aphanitic base, and have an average size of 2 to 3 mm., but individual crystals range up to 9 mm. in diameter. Small oval-shaped cavities containing chalcedony and calcite may be seen in some specimens, and where these have fallen out during weathering the rock presents a somewhat vesicular appearance. These cavities may represent in part an original vesicular structure, although some are undoubtedly due to replacement of augite phenocrysts by serpentine, calcite and secondary silica.

Microscopic Description.—Holocrystalline and porphyritic with a microcrystalline groundmass, which has in some sections a distinctly pilotaxitic fabric. Besides the phenocrysts of augite and hornblende observable in the hand specimen, some small phenocrysts of felspar also occur.

(i.) *Phase containing augite only* (slide x 32).

Augite isa pale yellow-green to almost colourless variety, and occurs in beautiful idiomorphic, well cleaved, crystals;

some crystals have an almost colourless central zone with an outer zone of yellowish-green. The crystals in general have a very fresh appearance, but some show various stages of alteration into serpentinous material and calcite. In those sections in which the augite only occurs it occupies up to 40% of the volume of the rock.

Felspar. This occurs in small idiomorphic crystals ranging up to 1 mm. in diameter, the average being about 0·5 mm. The quantity present varies considerably in different sections, reaching as much as 30%. These felspars are always much altered; any twinning noticeable is always multiple. A few approximate extinction determinations place it as being a basic andesine.

Iron ores.—Pyrite is the most plentiful, there being but little magnetite or ilmenite present, and this is mainly associated with the alteration of the augite.

Apatite is only sparingly developed.

Secondary minerals are abundant and include kaolin and sericite as alteration products of the felspars; serpentine, calcite and iron ores as alteration products of the augites; secondary silica due to infiltration.

Serpentine is the main product of the alteration of the augite and is sometimes completely pseudomorphous after that mineral. In this connection it is often associated with *calcite*, which in some sections is fairly abundant, and in patches up to 2 mm. in diameter. The serpentine also occurs filling oval or circular shaped cavities often in association with secondary silica, the latter occupying the central zone. Some of the cavities are filled completely with secondary silica largely chalcedonic in character, and showing well marked concentric structure. Pyrite is sometimes associated with the serpentine and secondary silica often forming a complete border zone.

The groundmass is microcrystalline with a pilotaxitic fabric in some sections. It is essentially a matrix of minute felspar laths with microscopic augite grains in which are embedded the phenocrysts. It is for the most part much altered and inclined to opacity. In some sections secondary silica is plentifully scattered through it in microscopic aggregates.

(ii.) *Phase in which hornblende occurs.*

In slide x 64, which is a good example, the hornblende is abundant in beautifully fresh crystals of a green colour, exhibiting strong pleochroism. Twinning is common, and some good zoning is present. The augite is generally above the average in size for this phase, one crystal measuring 3 mm. in diameter. It shows slight alteration to hornblende in places.

Augite-andesite phase (x 32).

Chemical Composition.

	Per cent.		Per cent.
SiO_2	53·62	Cl	trace
Al_2O_3 ...	12·10	$S(FeS_2)$ ...	trace
Fe_2O_3 ...	2·00	Cr_2O_3 ...	absent
FeO	6·30	NiO and CoO	trace
MgO	7·07	MnO	0·17
CaO	11·64	BaO	0·04
Na_2O ...	1·84	SrO	† trace
K_2O	1·52	Li_2O	absent
H_2O (100° C.)	0·22	V_2O_3... ...	0·02
H_2O (100° C.+)	1·86		
CO_2	1·12		100·33
TiO_2	0·50		
ZrO_2	absent	Specific gravity	2·892
P_2O_5... ...	0·29	Trace = less than 0·01%	
SO_3	0·02	† Spectroscopic reaction only.	

Norm.

	Per cent.		Per cent.
Quartz ...	6·00	Magnetite ...	3·02
Orthoclase ...	8·90	Ilmenite ...	0·91
Albite ...	15·20	Apatite ...	0·67
Anorthite ...	20·57	HO_2, CO_2 etc.	3·20
Diopside ...	28·61		
Hypersthene...	13·32		100·40

Class III. Salfemane. Rang 3. Camptonase.
Order 5. Gallare. Sub-rang 4. Camptonose.
Magmatic name Camptonose.

The high percentage of quartz in the norm would be accounted for in large part, if not entirely, by the amount of secondary silica present. The diopside and hypersthene molecules together with a portion of those allotted to anorthite would be combined to form the augite present, and thus give a good idea of the high percentage of that mineral.

Bearing in mind that a portion of the anorthite should be transferred to form the pyroxene, the average plagioclase felspar would probably approach a basic andesine or an acid labradorite. The amount of orthoclase present would be small. The fact that the felspars have undergone a good deal of alteration, resulting probably in a loss of some lime, should be taken into consideration when trying to arrive at the actual mineral constitution from the norm.

In taking a sample of this rock for analysis, fragments as free as possible from the secondary minerals were chosen, therefore the amount of these present, as shown in sections, would probably be more than indicated by the analysis.

(c) Augite Lamprophyre.

From McEwan's Creek, Locality A.

Megascopic Description.—A dark green aphanitic rock with numerous fresh looking augite phenocrysts. Small

patches of a darker and much softer serpentinous material are also abundant.

Microscopic Description.—Holocrystalline and porphyritic with a microcrystalline groundmass tending to a pan-idiomorphic fabric. The porphyritic constituent is augite, while the groundmass contains felspar, augite, biotite and apatite.

Augite.—The augite phenocrysts constitute 30 to 40% of the rock by volume; they have an average size of 1 to 2 mm., but crystals up to 4 mm. occur. It is a pale green to almost colourless variety, and occurs in beautifully fresh looking, idiomorphic, well cleaved crystals, sometimes showing typical examples of twinning; and are similar in every way to those occurring in the andesites at the Cave House. A serpentinous material is abundant, occurring in patches of about the same size as the augite phenocrysts. It is pale green to colourless and probably pseudomorphous after the augite. Except that a similar serpentinous material is noticed along cracks and cleavage directions in some of the augites, there appears to be no transition stage, as one would expect to find, between the remarkably fresh looking augite on the one hand, and the complete serpentine patches on the other.

The groundmass is comparatively fresh with a distinctly holocrystalline texture, the average grainsize being from 0·1 to 0·2 mm. It consists of felspar, with lesser amounts of augite and biotite, while fine needles of apatite are plentifully scattered through it.

Felspar is strictly confined to the groundmass, phenocrysts being typically absent. It has a general lath-shaped appearance and includes both plagioclase and orthoclase, the former predominating. The felspar would constitute about 40% of the rock by volume.

The *augite* occurs in typical stumpy crystals and is not quite so fresh looking as the phenocrysts. It is more abundant than the biotite.

The *biotite* is of a brown colour, and rather plentifully and regularly scattered through the groundmass. It is unaltered with fairly strong pleochroism; has a somewhat smudgy appearance, the outline of the crystals being indefinite, seldom distinctly idiomorphic.

Besides apatite the only other accessory minerals are iron ores, consisting chiefly of pyrite as small crystals and grains generally associated with the serpentine patches.

It will be seen that this rock differs from the porphyritic augite-hornblende-andesite of the Cave House in (*a*) containing a fair amount of biotite, (*b*) containing no hornblende, (*c*) its lamprophyric texture.

C. The Quartz Porphyrites.

As already pointed out in Part I, two distinct varieties of this rock occur, which owing to their colour were referred to as the pink and green varieties respectively. It will be seen from the following description, that not only do they differ in colour, but to some extent also both in their structure and chemical composition. The pink variety has a granophyric structure and quartz phenocrysts are not conspicuous. This will be described as a granophyric-quartz-porphyrite. The green variety does not display any granophyric structure, but is crowded with small quartz phenocrysts.

The classification of rocks of this type *i.e.*, of hypabyssal occurrence and of intermediate chemical composition, is a vexed question. If classified on a chemical and mineralogical basis only, a system some petrographers are strictly following, they would be placed with the dacites, *e.g.*, the green variety with the magmatic name Tonalose

would according to the quantitative scheme of classification outlined in Iddings' "Igneous Rocks," fall within Division II, Group C, *i.e.*, Quartz-diorites and their equivalent aphanites, to the latter of which he gives the name dacite or dacite-porphyry, the latter being the equivalent of the palæotypal variety quartz-porphyrite. Adopting the scheme in which mode of occurrence has also a bearing on nomenclature, and as outlined in Harker's text book "Petrology for Students," the name quartz-porphyrite[1] is applied.

(*a*) Granophyric Quartz-porphyrite (Pink Variety).

Megascopic Characters.—This rock has a pinkish-brown colour, mottled with dark green, creamy and light yellowish-green patches. It is porphyritic with an aphanitic base of a pinkish-brown colour. The phenocrysts present are chlorite, felspar and quartz. The chlorite is of a dark green colour, dull lustre, and varies considerably in size, reaching 5 mm., the average size being about 2 mm. Occasionally harder patches with a fair lustre are noticed, which represent not entirely altered phenocrysts of a ferro-magnesian mineral. Yellowish-green patches of what appears to be epidote are associated with the chlorite and scattered through the groundmass. Quartz occurs very sparingly as phenocrysts which are only noticed here and there with a diameter of about 1 mm. The felspar is pale yellowish-green to dull white in colour, and shows evidence of much alteration to kaolin etc. The average size of the crystals is about 2 mm., but ranges up to 4 or 5 mm. The chlorite and felspar phenocrysts appear to be developed in about equal proportions.

[1] Porphyrite as defined by Harker is a rock of hypabyssal type, with intermediate chemical composition and porphyritic structure with a groundmass, and characterised by a soda-lime felspar.

MICROSCOPIC CHARACTERS.—Slide x 888 is described in the main as being typical of the rock type. This rock is holocrystalline and porphyritic with medium to fairly coarse micro-crystalline groundmass. It is much altered, in some places to such an extent as to render description difficult. The phenocrysts in their order of abundance are felspar, augite, quartz, and would occupy between 30 and 40% of the rock by volume.

Felspar.—Is in an advanced stage of alteration and it is often difficult to define its boundaries, except between × nicols, as it merges into the groundmass in ordinary light. Both plagioclase and orthoclase are present, the former predominating; only occasionally is the multiple twinning of the plagioclase clear enough to obtain measurable extinctions, and approximate determinations place it about andesine. A faint zoning is sometimes seen. The colour is variable depending upon the type of alteration, being brownish, greenish, grey, clouded etc. The decomposition products are kaolin, sericite and chlorite mainly, with calcite and epidote. In some sections the phenocrysts are either completely sericitised or kaolinised; others show an alteration to both kaolin and sericite, often having a zonal arrangement, the outer zone being kaolin with the central part sericite; and others still are a mixture of kaolin, sericite, chlorite and calcite.

Quartz occurs only sparingly as phenocrysts and is of small size compared to the felspar; generally speaking it is more a constituent of the groundmass. Large and numerous phenocrysts as in the quartz-porphyrite being typically absent. It is often interstitial in habit, separated grains being often optically continuous.

Augite—Slide x 889, shows a very pale green augite somewhat sparingly in patches, not yet completely altered. In other slides, no trace of an original ferro-magnesian

mineral was detected. The augite when present is associated with its alteration products, chlorite mainly, calcite, epidote and iron ores. A few small phenocrysts of *hornblende* were noticed.

Iron ores (in part secondary). Both *ilmenite* and *magnetite* are present mainly in groups of grains and crystals associated with chlorite, where it represents segregations during the alteration of the ferro-magnesian minerals. It is also scattered sparingly through the groundmass. Ilmenite appears to be the most plentiful, but as they generally occur together, it is often impossible to distinguish between them. Ilmenite frequently shows a typical skeleton form of growth arranged in three parallel groups which cut each other at 60° in cross section. In some instances it is altered to leucoxene.

Apatite occurs in the matrix as small prisms and needle-like crystals. It is also rather plentifully included in the chlorite patches and less sparingly in the felspars. It is more abundant here than in the other types of rock described.

The secondary minerals are chlorite, calcite, kaolin, sericitic material and epidote.

Chlorite is the most abundant of these products and occurs in patches up to 5 mm. in size. It is present as an alteration product of the phenocrysts and the groundmass. It is undoubtedly the principal alteration product of a ferro-magnesian mineral, and from its association in x 889 with augite, it is probably in large part derived from that mineral. It is of a fibrous nature and pale green colour and generally faintly pleochroic. Between × nicols it shows a deep ultramarine blue, and in some instances is almost isotropic.

Calcite occurs rather plentifully, and according to the analysis occupies about two per cent. of the rock. It is an

alteration product of the ferro-magnesian minerals, felspar and groundmass.

Epidote is present both as an alteration product of the phenocrysts and of the groundmass. It is of a yellowish-green colour with fair pleochroism, and occurs as crystals with the typical columnar structure, and as irregular patches and grains. It is more plentiful in some slides than in others.

The groundmass.—This is generally much altered and does not admit of detailed description. It is of a yellowish or brownish clouded colour, changing to pale green where chlorite is plentiful. It may be briefly described as a micro-crystalline mixture of felspar, orthoclase and plagioclase, the former predominating, and quartz with the secondary products chlorite, kaolin, calcite and epidote. Quartz is fairly plentiful and is more or less interstitial in habit. Where the groundmass of this rock is at all fresh it shows distinct micrographic structure; especially is this the case in slide x 66 where exquisite examples of this structure occur, and in which it constitutes a large part of the groundmass. Frequently the groundmass encloses these patches of micropegmatite, like porphyritic crystals, with irregular boundaries, arranged around a centre and with an average size of about 0·4 mm. but reaching 1 mm. Often the orthoclase is twinned on the Carlsbad law when the structure assumes a delicate feather-like appearance, the composition plane of the orthoclase corresponding to the rib of the feather and the parallel intergrowths of quartz to the barbs.

This rock with its distinctly holocrystalline groundmass is inclined more to plutonic than volcanic types. In structure it is closely allied to the granophyres of the acid group. With a silica content reaching only 61%, and characterised by a porphyritic soda-lime felspar, it must however, be included in the intermediate group.

Chemical Composition.

	Per cent.		Per cent.
SiO_2	60·95	Cl	trace*
Al_2O_3 ...	15·05	S (FeS_2) ...	absent
Fe_2O_3 ...	2·60	Cr_2O_3 ..	absent
FeO	3·69	NiO and CoO	trace*
MgO	2·82	MnO	0·08
CaO	4·30	BaO	0·13
Na_2O ...	3·22	SrO	present†
K_2O	3·00	Li_2O	absent
H_2O (100° C.)	0·17	V_2O_3 ...	0·02
H_2O (100° C.+)	2·08	CuO	trace*
CO_2	0·80		
TiO_2	0·65		99·83
ZrO_2	absent		
P_2O_5	0·26	Specific Gravity	2·796
SO_3	0·02		

* Trace less than 0·01%. † Spectroscopic reaction only.

Norm.

	Per cent.		Per cent.
Quartz ...	16·68	Magnetite ...	3·71
Orthoclase ...	17·79	Ilmenite ...	1·22
Albite ...	27·25	Apatite ...	0·67
Anorthite ...	17·51	H_2O, CO_2. etc.	3·09
Diopside ...	2·04		
Hypersthene...	9·80		99·76

Class II. Dosalane. Rang 3. Tonalase.
Order 4. Austrare. Sub-rang 3. Harzose.
Magmatic name Harzose.

The diopside and hypersthene molecules together with some of those allotted to anorthite will constitute the pyroxene and its particular alteration product present in the rock. The plagioclase felspar is one which contains an excess of soda over lime and would approach andesine in character. This soda-lime felspar is in excess of the orthoclase, although the proportion of the latter is fairly high.

(b) The Quartz-porphyrite (Green Variety).

Megascopic Description.—The colour at a distance is dark green, near at hand it is dark green speckled white. The rock is porphyritic with an aphanitic groundmass. On casual inspection the rock appears to be phanerocrystalline, but on closer study the aphanitic character is distinctly seen; the phenocrysts of felspar and quartz being set in a matrix of chloritic material, the latter obscuring somewhat the aphanitic nature, and giving to the rock its prevailing green colour. The quartz phenocrysts are very plentiful and have an average size of from 1 to 2 mm., occasionally up to 4 or 5 mm. It is of a dark glassy to faint milky colour. With the aid of the lens the groundmass is seen to invade some quartz crystals.

The felspar is white to faint pink in colour, with an average size of 1 to 2 mm., occasionally ranging up to 4 mm. It is somewhat more plentiful than the quartz and shows various stages of alteration, some being fairly fresh in appearance, the majority, however, have a more or less dull lustre. Traces of twinning are consequently seldom noticed. Chloritic material of a greasy lustre and dark green colour comprises the balance of the rock. A yellowish green mineral of a secondary nature which appears to be epidote, is noticed here and there up to 3 mm. in size. Small fragments of foreign rocks, viz., limestone, slate, etc., are seen to be included occasionally, these are probably the remnants of larger lumps and blocks which have not been completely absorbed by the magma.

Microscopic Description.—The rock is holocrystalline and porphyritic with a microcrystalline base. Like the granophyric-quartz porphyrite, it is much altered, and description becomes rather difficult, especially in connection with the groundmass. Although chlorite is abundant and undoubtedly represents the alteration of a ferro-magnesian

mineral or minerals, in all the slides examined, primary ferro-magnesian minerals were not detected except in the case of a few flakes of biotite, included in the quartz and felspar phenocrysts. The primary minerals present are quartz, felspar, magnetite, ilmenite, and apatite. The secondary minerals are chlorite, kaolin, calcite, sericite, epidote, and iron ores in part.

Quartz occurs plentifully and is practically confined to the phenocrystic stage. The crystals vary in size (see megascopic description) till some approach fragments of microscopic dimensions, although the quartz enters but sparingly into the composition of the groundmass. Idiomorphic crystals are somewhat rare, the phenocrysts being generally of an angular or irregular form, where not otherwise rounded through corrosion. It also exhibits much fracturing, fragments of the same phenocryst often having slightly different extinction, but very little strain-shadowing, indicating subsequent differential movement of the fragments. This taken in conjunction with its angular character would appear to be the result of fracturing prior to the solidification of the rock, and due probably to change of molecular stress, consequent upon changes of temperature within the magma, subsequent to the crystallization of the quartz. Examples of typical corrosion are numerous, the groundmass commonly penetrating the crystals as tubular pockets or shallower bays, and often occurring as rounded inclusions. It is possible that such rounding of phenocrysts, inclusions and deep embayments of the groundmass, were formed during the crystallization of the quartz phenocrysts, and were due to an unequal supply of silica molecules from the magma, instead of being, as generally considered, the result of solution of the quartz by the magma.

Felspar is somewhat more plentiful than the quartz, and also ranges down to microscopic dimensions. It is often

idiomorphic, but a greater number of crystals are irregular or rounded in shape. It shows the typical method of corrosion along boundaries and lines of weakness as cleavage planes and cracks, instead of the pocket-like intrusions of of the groundmass, as in the case of the quartz. Plagioclase predominates, but the multiple twinning is too obscured by alteration to admit of the measurement of extinctions except here and there. The results of several determinations place it mainly as andesine, approaching in some to oligoclase-andesine. Orthoclase seems to be fairly plentiful, but this conflicts with the percentage of potash returned in the analysis, so a second determination of the alkalis was undertaken, on a sample secured recently at a different spot to that upon which the analyses were made, the material for which was collected some time previously:

	Recent sample.	Earlier sample.
Potash	0·56%	0·88% (analysis)

The quantity of orthoclase present in this rock must consequently be small. It is therefore probable that what is assumed to be orthoclase in section represents plagioclase twinned on the Carlsbad and albite laws, the finer lamellæ of the latter being obliterated by alteration, while the more prominent Carlsbad type is still noticeable.

The felspar is never fresh, but has undergone more or less alteration into kaolin, sericite, chlorite, calcite and epidote. These secondary products occur in abundance in the order named. The amount of alteration varies in different sections, some showing almost complete change to the above products.

Biotite—Only noticed on a few occasions as small flakes enclosed in felspar and quartz phenocrysts.

Iron ores—These occur as irregular patches and grains mostly associated with the light green chlorite patches, and no doubt here represent mainly an alteration product

of a ferro-magnesian mineral. It is sparingly scattered through the groundmass. A little of it appears to be leucoxene, but generally it is impossible to distinguish between the magnetite and ilmenite. A few specks of iron pyrites were detected with aid of lens in hand specimens.

Apatite occurs sparingly as small crystals in the chlorite patches and groundmass. It is included also occasionally as needle-like crystals in the felspars.

The secondary minerals are chlorite, calcite, epidote, kaolin, and a sericite-like material.

Chlorite is very plentiful and occurs in patches of a light green colour up to 2 or 3 mm. in size. The average size is about 1 mm. It is slightly pleochroic, shows very low interference colours, and is sometimes practically isotropic. It is probably the variety pennine. It undoubtedly represents, in a large part, the alteration of a ferro-magnesian mineral, and is often associated in this connection with calcite and iron ores. It also probably represents complete pseudomorphs after felspar as these show various stages of alteration. Chlorite, also of a fibrous nature, constitutes in large part the groundmass, giving to it the prevailing brownish-green to green colour. In most sections examined the matrix has been largely chloritised, in some completely so.

Calcite is fairly plentiful and would reach in quantity that indicated by the analysis, about 4%. It occurs sometimes in patches up to 3 mm. showing typical cleavage. Some of it no doubt is entirely secondary, *i.e.*, been introduced wholly into the rock by the action of percolating water, but the main bulk is probably due to the alteration *in situ* of lime bearing minerals by the action of percolating solutions containing carbonic acid. It is an alteration product of the felspar, ferro-magnesian mineral, and groundmass. The felspar shows various stages of alteration and

some of the calcite patches from their general appearance appear to represent complete pseudomorphs after that mineral. As a secondary product of a ferro-magnesian mineral it is often associated with the other alteration products, chlorite and iron ore.

Epidote of a yellowish-green colour is occasionally noticed as an alteration product of the phenocrysts and groundmass. It is rather plentiful in slide x 65, which shows typical replacement of felspar.

The other secondary products, kaolin and sericitic-material as already indicated, represent the alteration of the felspar.

The groundmass is microcrystalline, of a brownish-green colour. It is much obscured by alteration, and inclined to opacity, and does not admit of any detailed description. It is generally composed of felspar and its decomposition products, intimately mixed with a finely fibrous chloritic mineral. Wherever it penetrates the quartz and felspar phenocrysts it is of a brighter green, and more transparent, and illustrates well the alteration of the matrix into chlorite by infiltration. From the result of the analyses the conclusion is drawn that the felspar is essentially plagioclase, as the low percentage of potash would not allow much room for the presence of orthoclase, the potash present constituting orthoclase as phenocrysts. Microscopic quartz is present in small amount only. Calcite is scattered through it plentifully in patches and microscopic aggregates. A few inclusions of small fragments of other rocks were noticed, principally of sedimentary origin, viz., slate etc., also of a finer-grained igneous rock of a cognate type.

One of the features of this rock is the high proportion of phenocrysts to groundmass. This is apparent in both hand specimen and section, giving to the former a phaneo-crystalline appearance at first sight. The phenocrysts represent fully 75 per cent. of the rock by volume.

Chemical Composition.

	Per cent.		Per cent.
SiO_2	62·85	S (FeS_2) ...	absent
Al_2O_3 ...	13·58	Cr_2O_3 ...	absent
Fe_2O_3 ...	1·95	NiO and CoO	absent
FeO	5·45	MnO	0·14
MgO	1·92	BaO	0·10
CaO	4·10	SrO ...	† present
Na_2O ...	3·32	Li_2O	† absent
K_2O	0·88	V_2O_3... ...	trace *
H_2O (100° C.)	0·20	CuO	trace *
H_2O (100° C.+)	2·50		
CO_2	1·85		99·92
TiO_2	0·90		
ZrO_2	absent	Specific gravity	2·753
P_2O_5	0·18		
SO_3	trace*		
Cl	trace*		

* Trace less than 0·01%

† Spectroscopic reaction only.

Norm.

	Per cent.		Per cent.
Quartz ...	25·56	Ilmenite ...	1·67
Orthoclase ...	5·56	Apatite ...	0·34
Albite ...	27·77	HO_2, CO_2 etc.	4·55
Anorthite ...	19·74		
Hypersthene...	11·80		99·77
Magnetite ...	2·78		

Class II. Dosalane. Rang 3 Tonalase.
Order 4. Austrare. Subrang 4 Tonalose.
Magmatic name Tonalose.

Arriving at the actual mineral constitution from the norm, it is evident that the average plagioclase felspar is one in which soda predominates over lime, and, therefore, approximates to the andesine group, and plagioclase also largely predominates over orthoclase.

Both in hand specimens and under the microscope this rock is seen to be distinct in character from the granophyric quartz-porphyrite already described. Quartz phenocrysts are abundant and typical of this rock, and the quartz is practically confined to the phenocrystic stage, and enters only slightly into the composition of the groundmass. In the granophyric quartz-porphyrite, quartz as phenocrysts is only sparsely present, but it enters largely into the composition of the groundmass. The extreme chloritization of the groundmass of quartz-porphyrite is also very characteristic.

The analyses of both these rocks is somewhat similar, except in the percentages of potash present. The amount of potash in each is characteristic and constant, as already indicated by two determinations of the alkalis of material collected from different places. This difference is manifested mineralogically by the proportions of orthoclase present in each, being much more plentiful in the granophyric-quartz-porphyrite, and giving rise in it, in conjunction with the quartz, to the fairly abundant micropegmatitic structures.

The texture of the groundmass of the latter is also distinctly coarser and the rock generally approaches a more plutonic type. From a petrographical and chemical aspect these two occurrences appear to represent separate intrusions, as opposed to considering them as different phases of the one intrusion.

D. The Quartz Felsites.

The specimen selected for description is from the road-cutting at the head of Hinchman's Creek, (Slide x 894).

Megascopic Description.—Colour greyish-green to white. The groundmass has a distinctly felsitic appearance and contains numerous small phenocrysts of quartz and

felspar. Some specimens show evidence of intense silicification, the groundmass in some instances being completely changed to a fine-grained compact quartz.

Microscopic Description.—The rock is holocrystalline and porphyritic with a cryptocrystalline to microcrystalline groundmass. The phenocrysts, quartz and felspar occupy from about 10 to 15 per cent. of the rock. They are present approximately in equal quantity and generally of about the same size.

The quartz is irregular in outline and shows more or less corrosion, numerous instances of a typical character being noticed. Shadowy extinction is sometimes present.

Felspar.—Both orthoclase and plagioclase are present the latter predominating. The average size being from 0·5 to 1 mm. It is never quite fresh, being somewhat kaolinised and of a faint cloudy appearance. The amount of alteration is not so great as in the quartz-porphyrites. It generally shows incipient alteration to sericite, microscopic whisps of that mineral being scattered through the phenocrysts. Extinctions measured from the twin lamellæ of the plagioclase gave angles corresponding to albite. The orthoclase only occasionally shows twinning. The phenocrysts generally show more or less rounding through corrosion. Calcite occurs as an alteration product replacing the felspar along cleavage directions and cracks, also on boundaries, some of the phenocrysts being completely enveloped by a border of calcite.

Apatite is very sparingly present as needle-like crystals in groundmass, and to a less extent in the felspars.

Iron ore is scantily scattered as microscopic grains through the groundmass. Here and there small aggregates occur. A little iron pyrites was detected.

Calcite etc. is plentiful, occurring as grey patches up to 1 mm. in size and also scattered microscopically through the groundmass. It shows strong absorption and rarely traces of cleavage. It is an alteration product of the felspar, both phenocrysts and in groundmass. The amount present in this rock is high, as indicated by the presence of 2·83% of CO_2 in the analysis. No doubt magnesite and possibly dolomite are present, as it is not at all likely that the lime only is combined with the CO_2. The appearance of the carbonate mineral in section suggests this also. The carbonates are due in part to infiltration and not entirely the result of the alteration *in situ* of lime-bearing minerals.

The groundmass is cryptocrystalline mainly, to microcrystalline in texture, and is generally distinctly felsitic in character. It is of a grey colour and somewhat altered to a kaolinised product. Where determinable, it is seen to be composed of a microscopic mixture of orthoclase and quartz, the former predominating. Flow structure is well marked in places. Calcite is plentifully scattered through it in large patches and also in microscopic aggregates. A little sericite has also developed mainly along lines of flow. Some sections show complete silicification of the groundmass to a microcrystalline granular quartz.

Chemical Composition.

	Per cent.		Per cent.
SiO_2	70·40	CO_2	2·83
Al_2O_3 ...	13·13	TiO_2	0·30
Fe_2O_3 ...	1·25	ZrO_2	absent
FeO	1·75	P_2O_5	0·08
MgO	0·64	SO_3	* trace
CaO	2·74	Cl	trace*
Na_2O ...	3·47	S (FeS_2) ...	absent
K_2O	2·22	Cr_2O_3 ...	absent
H_2O (100° C.)	0·15	NiO and CoO	absent
H_2O (100° C. +)	1·35	MnO... ...	0·04

	Per cent.		Per cent.
BaO	0·04	CuO	trace*
SrO ...	† present		
Li_2O	absent		100·39
V_2O_3... ...	absent		
		Specific gravity	2·688

* Trace less than 0·01% † Spectroscopic reaction only.

Norm.

	Per cent.		Per cent.
Quartz ...	34·86	Magnetite ...	1·86
Orthoclase ...	12·79	Ilmenite ...	0·61
Albite ...	29·34	Apatite ...	0·34
Anorthite ...	12·51	H_2O, CO_2 etc.	4·41
Corundum ...	0·41		
Hypersthene...	3·18		100·31

Class I. Persalane. Rang 2 Alsbachase.
Order 3 Columbare. Sub-rang 4 Alsbachose.
Magmatic name Alsbachose.

Bearing in mind that the lime in the anorthite and hypersthene molecules, is represented in the rock mainly by calcite, which is in part due to infiltration, the plagioclase must be essentially a soda variety.

Another example of quartz-felsite, also from the road-cuttings at the head of Hinchman's Creek (Slide N 2) shows the following points of difference from that just described: (1) the quartz phenocrysts predominate largely over the felspar. (2) The comparative paucity of this rock in plagioclase, indicated by the much lower percentage of soda present, the amounts as given in the analyses being respectively (x 894) 3·47 per cent. and (N 2) 0·98 per cent. (3) Flow structure is more marked and there is a much greater development of sericite which forms a plentiful constituent

of this rock. The sericite occurs largely along lines of flow, and its appearance along certain planes as this would suggest that it is an alteration product as the result of pressure. The apparent flow structure might therefore be in part a foliation due to dynamic action subsequent to consolidation. The strain-shadowing sometimes noticed in the quartz phenocrysts, with some fracturing, and the remarkably bent felspar phenocrysts (slide x 52) may also have been due to dynamic action, but these characteristics could have been produced prior to consolidation, *i.e.*, during flow.

(4) Carbonates are more plentiful in this rock, the analysis of which gives 6·01 per cent. of CO_2. The calcification etc. is due in large part to infiltration instead of the alteration *in situ* of lime or magnesia bearing minerals. The analysis indicates that there is not enough CaO present (4·56%), to satisfy all the CO_2 to form calcite, therefore some of the CO_2 must be combined with the MgO, to form magnesite or dolomite, with probably a little isomorphous ferrous carbonate. The presence of ferrous carbonate is indicated by the separation of yellow oxide of iron from the carbonate patches.

Chemical Composition.

	Per cent.		Per cent.
SiO_2	63·22	H_2O (100° C.)	0·26
Al_2O_3 ...	13·57	H_2O (100° C. +)	2·10
Fe_2O_3 ...	1·50	CO_2	6·01
FeO	2·07	TiO_2	0·50
MgO	1·80	MnO	0·09
CaO	4·56		
Na_2O ...	0·98		100·48
K_2O	3·82		

NOTE.—The rock and slide numbers quoted refer to registered specimens and rock sections in the Sydney and Newcastle Technical College collections.

Table of Analyses.

	I.	II.	III.	IV.	V.	VI.	VII.
SiO_2 ...	74·18	50·05	53·62	60·95	62·85	70·40	63·22
Al_2O_3 ...	11·15	19·56	12·10	15·04	13·58	13·13	13·57
Fe_2O_3 ...	0·90	0·90	2·00	2·60	1·95	1·25	1·50
FeO ...	1·31	6·48	6·30	3·69	5·45	1·75	2·07
MgO ...	0·62	6·30	7·07	2·82	1·92	0·64	1·80
CaO ...	1·35	5·20	11·64	4·30	4·10	2·74	4·56
Na_2O ...	1·00	2·49	1·84	3·22	3·32	3·47	0·98
K_2O ...	5·86	3·09	1·52	3·00	0·88	2·22	3·82
H_2O(100°C)	0·15	0·43	0·22	0·17	0·20	0·15	0·26
H_2O(100°C+)	1·27	3·90	1·86	2·08	2·50	1·35	2·10
CO_2 ...	2·00	0·32	1·12	0·80	1·85	2·83	6·01
TiO_2 ...	0·25	0·55	0·50	0·65	0·90	0·30	0·50
ZrO_2 ...	absent	absent	absent	absent	absent	absent	...
P_2O_5 ...	0·15	0·38	0·29	0·26	0·18	0·08	...
SO_3 ...	trace	0·03	0·02	0·02	trace	trace	...
Cl ...	trace	trace	trace	trace	trace	trace	...
S(FeS_2) ...	0·01	trace	trace	absent	absent	absent	...
Cr_2O_3 ...	absent	absent	absent	absent	absent	absent	...
NiO & CoO	absent	trace	trace	trace	absent	absent	...
MnO ...	0·02	0·09	0·17	0·08	0·14	0·04	0·09
BaO ...	0·10	0·15	0·04	0·13	0·10	0·04	...
SrO ...	trace	trace	trace	trace	trace	trace	...
Li_2O ...	absent	absent	absent	absent	absent	absent	...
V_2O_3 ...	absent	0·05	0·02	0·02	trace	absent	...
CuO ...	trace	...	...	trace	trace	trace	...
	100·32	99·97	100·33	99·83	99·92	100·39	100·48

I.—Rhyolite-porphyry from near Grand Arch.

II.—Andesite (fine grained, non-porphyritic type) from near Caves House.

III.—Augite-andesite (porphyritic type) occurring as inclusions in II. from near Caves House.

IV.—Granophyric-quartz-porphyrite (pink variety).

V.—Quartz-porphyrite (green variety).

VI. } VII. } Quartz-felsite from road cutting at head of Hinchman's Crk.

TWO LORD HOWE ISLAND POLYPODIA.

By the Rev. W. WALTER WATTS.

[*Read before the Royal Society of N. S. Wales, December 1, 1915.*]

IN the earlier determinations of the Ferns of Lord Howe Island, too much appears to have been taken for granted; and, unfortunately, the two short papers published by me in the Proceedings of the Linnean Society of New South Wales,[1] in 1912 and 1914, rested upon the decisions of the earlier pteridologists, save in two cases, which resulted in the publication of *Asplenium bulbiferum*, var. *howeanum*, var. nov., determined earlier, at least in Sydney, as *Asplenium pteridoides* Bak.; and *Polystichum Whiteleggii*, sp. nov., known earlier as *Aspidium capense* (*Polystichum adiantiforme*). Recently I have seen reason to question the correctness of the view, that the two *Polypodia*, of the section *Grammitis*, found on the island, are respectively *P. australe* (R. Br.) Mett. and *P. Hookeri* Brack. My scepticism related, first, to the supposed *P. Hookeri*, but soon extended to the associated species.

I. *Polypodium Hookeri* Brack. belongs to a series of ferns, mostly tropical or subtropical, which have been involved in considerable confusion. They belong to the *Grammitis* group, *i.e.*, small *Polypodia* with undivided fronds; and they are clothed, more or less densely, with reddish-brown hairs. Dr. Christ[2] makes of them a Section "Setigera," but selects, for mention, only *P. setigerum* Bl. and *P. Hookeri* Brack. *P. Hookeri* was named *P. setigerum* by Hook. and Arn. in 1832, they having apparently overlooked Blume's *P. setigerum* published in 1828; the name was changed by Brackenridge in 1854.

[1] Vol. XXXVII, part 3, and Vol. XXXIX. part 2.

[2] Die Frankräuter der Erde, 1897, p. 78.

Blume,[1] in 1828, had described and figured several species of this group; but Hooker,[2] in 1862, in a note following his description of *Polypodium hirtum* Hook., said, "The smaller Indian grammitoid Polypodia, if I may so call them, are attended with great difficulty in their study, and neither the costly figures nor the descriptions of Blume tend so much as they ought to do to remove the difficulties." Mettenius, he adds, referred to three of Blume's species as belonging to *Grammitis hirta* Bl. Christensen (Index Fil.) identifies Blume's *G. hirta* (also *G. setosa* Bl.) with *Polypodium diplosorum* Christ (1896). Hooker, in describing his own *Polypodium hirtum*, expressed a doubt as to whether it was the *P. hirtum* of Mettenius *(vide supra).* Christensen, *loc. cit.*, makes Hooker's *P. hirtum* cover three separate species, viz., *P. diplosorum* Christ, *P. Reinwardtii* (Bl.) Pr., and *P. pubinerve* (Bl.) Christ. The result of all this is, that the name, *Polypodium hirtum*, has lost validity, and has disappeared, except as a synonym. This example of the difficulties that beset the "grammitoid Polypodia" is given, because, curiously enough, while in the Sydney National Herbarium the Lord Howe plant is labelled *P. Hookeri*, in Hooker and Baker's Synops. Fil., p. 320, one of the localities given, for *P. hirtum* Hook., is "Lord Howe's Island, C. Moore." In my opinion, the Lord Howe hairy Grammitis differs, in essential respects, from any of the described species within my knowledge, and must be regarded as a new species.

POLYPODIUM (GRAMMITIS) PULCHELLUM, sp. nov.

(*P. Hookeri* Brack. et *P. hirtum* Hook. in Herbariis err.)

Rhizoma robustiusculum, subrepens vel subadscendens, densissime fibrillosum, sæpe cum parvis discis (ostendentibus casorum bases stipitum) multo præditum, apice dense paleaceum, paleis subintegris, brunneis, a basi latâ lineari-lanceolatis, acumine in

[1] Enum. Fil. jav. p. 106 ff. [2] Sp. Fil., IV, p. 170, fig. 273 A.

longam, subflexuosam, integram setam, interdum geminam, producto. Stipites dense approximati, subcæspitosi, c. 3 – 4 cm. longi, in attenuatam frondis laminam mergentes. Frons integra, 1 – 2 dm. longa, et cir. 1 cm. lata, basin versus sensim tenuissime angustata, supra oblongo-lanceolata, breviter acuminata, acumine obtusiusculo, utrisque faciebus (et marginibus, stipitibus, et soris) cum levibus, integris, brunneis, longiusculis, subflexuosis pilis præditis; nervo tenui, fere ad apicem attingenti, venulis erecto-patentibus, plerumque dichotomis, interdum trifurcatis, furcis fere ad marginem attingentibus; soris sat numerosis, obliquis, in seriebus singulis, subjuxtacostalibus, dispositis, juventate sublinearibus, maturitate ovalibus, prope basin superioris furcæ venulæ positis. Textura tenui-coriacea.

On the upper slopes and the summit of Mount Gower; also on Mount Lidgbird.

This handsome little fern differs from *P. Hookeri*, (1) in size: it is considerably larger; (2) in venation: in *P. Hookeri* the lower fork of the dichotomous venule is much longer than the short upper one that bears the sorus, while in our species the two forks (sometimes three) are of equal or nearly equal length; (3) in the shape and position of the sori, which, in *P. Hookeri*, are larger, rounder, more closely set in the rows, and closer to the midrib; (4) in the surface hairs, which are shorter and stiffer in *P. Hookeri;* (5) especially in its basal scales, which are very short and broad, and lighter in colour, in *P. Hookeri;* (6) in texture: the veins in our species are, with a lens and transparent light, more or less visible, while in *P. Hookeri* they are altogether obscured.

The basal scales of *P. pulchellum* are apparently quite distinctive, with their long, sometimes geminate, setæ, which character would have made the name *P. setaceum* suitable, but for its too close approximation to *P. setigerum* Bl. and the syn. *P. setosum.*

II. Polypodium (Grammitis) howeanum sp. nov.

(*P. australe* in Herbariis err.)

Rhizoma robustiusculum, adscendens vel subcæspitosum, densissime fibrillosum, apice dense paleaceum, paleis longiusculis, lanceolatis, subflexuosis, mollibus, longe subulatis, subula flexuosa. Stipites dense approximati, glabri, fere ad basin per attenuatam frondis laminam alati, plus minusve brunnei. Frons glaberrima, integerrima, ad 3 dm. vel ultra longa et prope ad 1 cm. lata, sed plerumque multo angustior, sicca subfalcata, distincte recurva, infra longissime in brevem stipitem sensim attenuata, supra oblongo-lanceolata, longe acuminata, nervo valido, fere percurrente, subtus prominenti; venulis numerosis, dichotomis, utrisque furcis equalibus vel subequalibus, fere ad marginem attingentibus, erecto-patentibus, indistinctis; soris in superiore tertia frondis parte et in superioribus furcis venularum positis, obliquis, sublinearibus, sæpe confluentibus. Color dilute viridis, haud nitens. Textura coriacea.

Upper slopes and summit of Mount Gower, also on Mount Lidgbird; often associated with *P. pulchellum*.

Hitherto identified with *P. australe* (R. Br.) Mett., from which, however, it differs through its stouter rhizome, its much longer fronds, its long, subulate, flexuose scales, its very short, smooth stipes, and, especially, its finer and more closely set venules with their long equal or nearly equal forks. *P. australe* has venules with one long fork and one short one (bearing the sorus); it also shows its venules more or less distinctly in slightly raised ridges on the upper surface, and its venules are much farther apart than those of *P. howeanum*. The fronds, also, of *P. australe* are more or less distinctly crenulate.

NOTES ON THE NATIVE FLORA OF TROPICAL QUEENSLAND.

By R. H. CAMBAGE, F.L.S.

With Plates LVII – LXI and Map.

[*Read before the Royal Society of N. S. Wales, December 1, 1915.*]

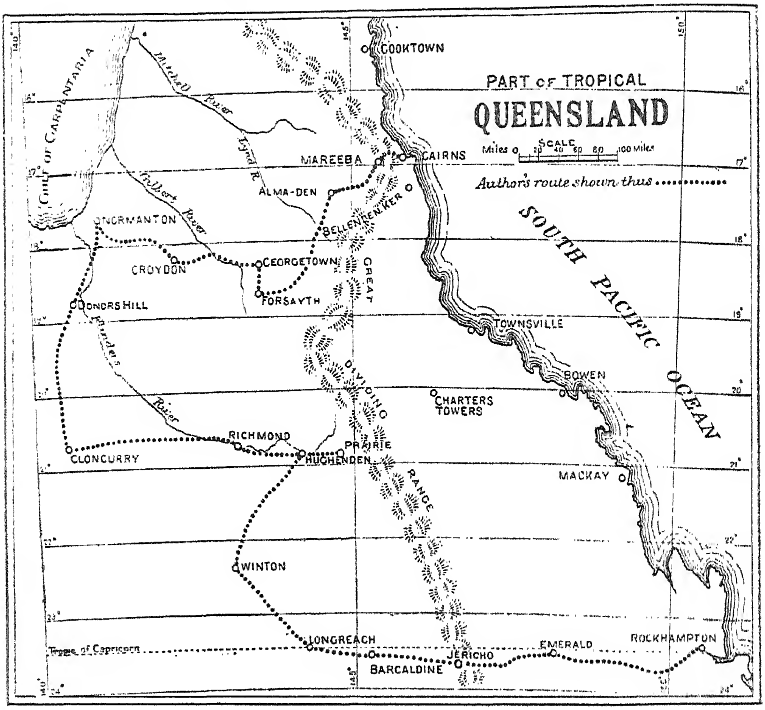
THE notes for this paper were obtained during a visit to Queensland in August 1913, and the references are practically confined to the conspicuous members of the flora as seen from the train and coaches, and as examined and discussed with bushmen during stoppages of a few hours in various localities. The route followed was from Cairns to Alma-den, Forsayth, Georgetown, Croydon and Normanton on the Gulf of Carpentaria. From Normanton the journey was continued to Cloncurry, Hughenden, Prairie, Winton, Longreach and Rockhampton.

By far the greater portion of the area traversed is west of the Great Dividing Range, and consequently the vegetation for the most part consists of open forest. The same conditions prevail in Queensland as in New South Wales in regard to the eastern and western floras being responsive to the moist and dry climates respectively.[1]

Cairns is situated a few feet above sea-level, at the base of steep mountains whose eastern sides are clothed with luxuriant brush (the term scrub is used in Queensland) or jungle to their summits. To the westward of Cairns the Main Divide is crossed by the railway at about 1,700 feet above sea-level, while about thirty miles southwards from Cairns the great mountain masses of Bellenden Ker and

[1] Mountains of Eastern Australia and their effect on the Native Vegetation. By R. H. Cambage. This Journal, XLVIII, (1914), p. 267.

Bartle Frere rise to elevations exceeding 5,000 feet, and these are for the most part walls of brush to within a few feet of their actual crests. In all these mountain scenes, the Malayan element of the tropical flora, which includes fig trees, climbing vines, palms, dense jungle, etc., adds a magnificence and grandeur unsurpassed, and in only a few instances equalled in any portion of Australia.



The impressions formed by botanists from the Southern States on arrival at Cairns will vary to some extent according to the season of the year, and flowering plants which may appear common at one season may be scarcely noticed at others. One cannot fail to be impressed however, with the tropical nature of the flora, and in the course of a short

walk many plants are met with which are never seen wild in the latitude of Sydney, but which are recognised as cosmoplitan tropical types.

Within the limits of the town may be seen huge spreading examples of various species of *Ficus;* shapely trees of *Wormia alata* Rottb., (Dilleniacæ), with beautiful large yellow flowers three inches in diameter, and large oval leaves with winged stalks; palm-like arborescent plants of *Pandanus aquaticus* F.v.M., ? (Pandanaceæ); shrubs of *Tabernæmontana orientalis*, R.Br.,(Apocynaceæ), rendered conspicuous by the three-angled, falcate, yellow fruits; small plants of *Vinca rosea* Linn., (Apocynaceæ), a naturalised species common in the sand; beach plants of *Ipomœa pes-capræ* Roth., (Convolvulaceæ), common on the sea coasts of most tropical countries; masses of succulent herbaceous plants, near the beach, of *Bryophyllum calycinum* Salisb., (Crassulaceæ), a naturalised plant several feet high with attractive reddish-green to pink tubular flowers, from tropical Africa; large trees of *Castanospermum australe* A. Cunn., (Leguminosæ), Moreton Bay Chestnut or Bean Tree; smaller trees of *Alphitonia excelsa* Reissek., (Rhamnaceæ), a species distributed from the Pacific Islands to the south coast of New South Wales, where it is in places known as Red Ash, and whose identication is assisted by its clusters of berry-like drupes, and leaves with an almost white underside; tall twining plants of *Hardenbergia retusa* Benth., (Leguminosæ) with beautiful purple flowers; species of Macrozamia, Melaleuca, and phyllodineous Acacias, including *A. aulacocarpa* A. Cunn., with its falcate phyllodes and spike flowers; and *A. flavescens* A. Cunn., with its prominently three-nerved, broad phyllodes, with sinuate upper margins, and its flowers in globular heads.

BELLENDEN KER.

An ascent was made of Bellenden Ker from the Harvey's Creek side, but it is not proposed to give an account of its flora, as a comprehensive list has already been published by F. Manson Bailey, Colonial Botanist, Queensland.[1] The ascent, though strenuous, may be conveniently made from Harvey's Creek, but it is necessary to secure a guide as there is no track whatever.

The beautiful *Dracophyllum Sayeri* F.v.M.(Epacridaceæ), was found flowering on the summit in August. This is the only species of Dracophyllum recorded for Queensland, and although the genus is represented in New Caledonia, Lord Howe Island, and Western Australia, its home is usually regarded as being in southern latitudes.

The native guides, one of whom had spent much of his early life on the slopes of Bellenden Ker before the arrival of white men, gave me several native names of plants. It seems evident that in their wild state the natives kept very much to their own districts in this rough, wooded country, for different dialects arise at fairly short distances. As an example, the native names of Bellenden Ker and Bartle Frere have been recorded from the Russell River dialect as Wooroonooran and Chooreechillum respectively;[1] while the names given me by natives representing the Harvey's Creek dialect, a dozen miles away, were Charorjimburra (the accent being on the third syllable), and Chigweaya (the accent being on the first *a* or third syllable).

Among the native names (Harvey's Creek dialect), supplied of plants on the lower slopes of Bellenden Ker were the following:—

[1] Report of the Government Scientific Expedition to Bellenden Ker Range (1889). See also "Botanical Notes in Queensland, the Mulgrave River," by Rev. J. E. Tenison-Woods. Proc. Linn. Soc. N.S. Wales, Vol. VII, (1882), p. 305.

Elæocarpus grandis F.v.M., "Mooregan" (Tiliaceæ, Blue Fig or Quandong).

Castanospermum australe, "Dongera" (Moreton Bay Chestnut or Bean Tree).

Backhousia Bancroftii Bailey et F.v.M., "Cowarda," with the accent on the first syllable, (Myrtaceæ, Johnstone River Hardwood).

Alstonia scholaris R.Br., "Jalgan," (Apocynaceæ, Milky Pine).

Cordyline terminalis Kunth., "Midgenbil" (Liliaceæ, Lily Palm).

Colocasia macrorrhiza Schott., "Culgum," (Aroideæ, Cunjevoi of the natives of parts of the southern Queensland coast). Some of these plants were noticed to be prostrate, and it was pointed out by the natives that the roots are eaten by the Brush Turkeys (*Talegallus Lathami)* which undermine the plants when scratching for their food. This is evidently the plant referred to by Professor Baldwin Spencer as being eaten by the Native Turkeys near Cooran, south of Gympie.[1]

Angiopteris evecta Hoffm., "Chillimother," (Filices). A beautiful tree-fern with a short trunk and remarkably long fronds, often upwards of twelve and fifteen feet. Locally called Water Tree-Fern, from being commonly found on the banks of creeks. It ranges over tropical and Eastern Asia to Japan and extends from Madagascar to the Pacific Islands.[2]

As showing the effect of warmth and moisture on poor soils, it may be mentioned that the greater portion of Bellenden Ker, which has an excessive rainfall, over 150 inches annually, is covered with brush, although the granitic rock at the summit contains about 72% silica, and yields a

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[1] Victorian Naturalist, Vol. IX, (1892) p. 32.

[2] B. Fl., Vol. VII, p. 694

soil which in cooler latitudes south of Sydney would be too siliceous for the growth of Jungle flora. I am indebted to Mr. J. C. H. Mingaye, F.C.S., for the amount of silica content in this rock.

NATIVE LEGENDS OF BELLENDEN KER.

Mr. John Hill of Glen Boughton, Cairns, who ascended this mountain over twenty years ago, gave me the following interesting folk-lore which he obtained through a native interpreter from a very old blackfellow named Merrewah, who acted as one of the guides. During their ascent it was noticed that on three occasions after a long climb, a small level zone was reached. These zones, Merrewah explained, were up to that time used as camping grounds by the natives when making their flying hunting trips on these mountains, and were swept clean for spaces of ten to twenty feet. They were known as "plarriah" and denoted by numbers. Each plarriah had certain tribal responsibilities and laws attached to it. Thus up to No. 1 plarriah could go the women and children with the hunters; to No. 2 could go the men accompanied by the lads up to ten or twelve years old, who had then to return to their waiting mothers at No. 1. Then up to No. 3 plarriah (embracing the whole summits characterising the Bellenden Ker Mount), only the adult men could go, who had been through the full initiation ceremonies of manhood. Old Merrewah went on to explain that the legends of the tribe told how one disobedient boy of about twelve years, surreptitiously followed his father on to the plateau of No. 3 plarriah, and that while his father was hunting for the Mappee, (the tree-climbing kangaroo, *Dendrolagus Lumholtzii*), he suddenly was horrified to hear his son close by calling piteously for help. Running to the sounds he looked up to the top of a tall tree to see the evil spirit embracing his boy. The father wept and implored the evil spirit to let the boy go

or bring him down, but the fiend only laughed and threatened to drop him. At last, exasperated, the father hurled his spear at the fiend and impaled him through the abdomen, when he let go of the boy, and the father opening his mouth caught his son safely.

It is well known that the natives had a curious dread of some evil spirit on the summits of these mountains, and an elderly blackfellow who was one of my guides, had never been to the actual top of Bellenden Ker until he went with me in August 1913.

Mr. Hill relates that his party passed an enormous fig tree growing in a peculiar depression down the slope. Merrewah pointing to the tree said, (through the interpreter), in that tree the first mappees which lived in this region started their existence, male and female; but gradually they so increased in numbers that one night the whole tree and the ground beneath it collapsed under their weight, and the tree-climbers found themselves being buried under the earth. Ultimately, by following an underground channel, two of them, male and female again, found themselves on the surface. This worthy couple, decided that never again would they or their descendants live more than two in a tree together, and this custom, Merrewah continued, they follow to the present day.

Mr. Hill adds that it is a fact that only two of these animals are ever found together, and they do not go in numbers like their near relatives, the Rock Wallaby (*Petrogale penicillata*).

KURANDA TO MAREEBA AND ALMA-DEN.

Kuranda is situated near the famous Barron Falls, twenty-one miles by railway from Cairns, and at about 1,100 feet above sea-level. The spot is just at the summit of the steep ascent from Cairns, and on the eastern margin of a gently rising plateau.

About five miles past Kuranda, the effect of the change of climate from the wet and humid conditions of the coastal belt to the drier atmosphere of the western side of the mountains is most marked, and is evident in the resultant flora. In less than thirty miles from Cairns, practically the whole of the jungle flora is left behind, and is seen no more on the way to Normanton. The geological formation of a considerable area between Mareeba and Alma-den is granite.

From Kuranda to Alma-den the following species were noted:—

DILLENIACEÆ: *Hibbertia volubilis* Andr. (Seen only around Kuranda).

RHAMNACEÆ: *Alphitonia excelsa* Reiss. (At various points).

LEGUMINOSÆ: *Castanospermum australe* A. Cunn. (Moreton Bay Chestnut. Seen only around Kuranda), *Acacia flavescens* A. Cunn., *A. aulacocarpa* A. Cunn., *A. auriculiformis* A. Cunn., *A. cincinnata* F.v.M. (with compact spiral pods).

MYRTACEÆ: *Callistemon viminalis* Cheel (at Biboohra), *Melaleuca leucadendron* Linn. ? var. *Cunninghami* Bailey, *Eucalyptus leptophleba* F.v.M., *E. melanophloia* F.v.M., (Silver-leaved Ironbark), *E. crebra* F.v.M., (Narrow-leaved Ironbark), *E. miniata* A. Cunn., *E. tereticornis* Sm. (Forest Red Gum), *E. alba* Reinw. (*E. platyphylla* F.v.M.), *E. pellita* F.v.M., (large fibrous barked trees between Kuranda and Barron Falls, with fruits 1·6 cm. in diameter), *E. papuana* F.v.M. (*E. tesselaris* F.v.M. var. *Dallachiana*? Cabbage Gum), *E. corymbosa* Sm. (Bloodwood), *E. sp.* (Stringybark, between Oaklands and Koah), *E. dichromophloia* F.v.M.? (Red Bloodwood), *Tristania suaveolens* Sm., *Rhodamnia trinervia* Blume, (at Kuranda), *Careya australis* F.v.M., (at intervals all the way, often showing a few red leaves).

MELASTOMACEÆ: *Melastoma malabathricum* Linn. (At Kuranda).

LORANTHACEÆ: *Loranthus longiflorus* Desr.

COMPOSITÆ: *Helichrysum sp.?* (white flower with black centre, on granite hills between Boonmoo and Petford)

BIGNONIACEÆ: *Spathodea heterophylla* R.Br.? (at Kuranda).

PROTEACEÆ: *Persoonia falcata* R.Br., (10 to 15 feet high. Near Lappa Junction, 1900 feet above sea level), *Helicia Nortoniana* Bailey, (at Kuranda on slate formation), *Grevillea chrysodendron* R.Br., with beautiful yellowish-red flowers, *G. polystachya* R.Br., *G. gibbosa* R.Br., (Beef tree).

EUPHORBIACEÆ: *Homalanthus populifolius* Grah. (*Carumbium populifolium* Reinw.).

URTICACEÆ: *Ficus opposita* Miq., *Cudrania javanensis* Trecul. (Cockspur Thorn, near Kuranda).

CASUARINACEÆ: *Casuarina suberosa* Ott. and Dietr., (Black Oak), *C. torulosa* Ait., (Forest Oak), *C. Cunninghamiana* Miq. (River Oak), *C. Luehmanni* R. T. Baker, (Bull Oak).

CONIFERÆ: *Callitris sp.* (Pine), *Agathis robusta* C. Moore, (Queensland Kauri Pine, seen around Kuranda).

CYCADACEÆ: *Macrozamia sp.* (between Boonmoo and Lappa Junction).

JUNCACEÆ: *Xerotes longifolia* R. Br.

PANDANACEÆ: *Pandanus aquaticus* F.v.M.?

GRAMINEÆ: *Imperata arundinacea* Cyr. (Blady grass, seen only near Kuranda).

Amongst the Acacias of North Queensland is a considerable percentage of those belonging to the sections Plurinervæ and Julifloræ. *A. auriculiformis* was noticed at Kuranda and also on the side of Bellenden Ker, where some of the trees were 70 to 80 feet high and 3 to 4 feet in diameter.

Eucalyptus leptophleba was noticed soon after the forest country was entered, and it extends westerly to Alma-den and towards Forsayth, but from about this latter locality

it seems to give place to a smaller and paler coloured form of Box Tree (No. 4162) which was found intermittently as far west as the Flinders and Cloncurry Rivers. *E. leptophleba* is a Box tree with a rather thick bark and long leaves, the rough bark extending to the branchlets. The timber is reddish-brown with a fairly thick sapwood. It seems to favour the low, rather than the hilly land.

E. alba (Poplar Gum) is fairly common along the coast and was noticed as far inland as towards Dimbulah. It is a white gum with very large juvenile leaves, measurements of nine by six inches being not uncommon. It appears to often grow on a granite formation which contains about 70° silica. A note taken at Townsville, while near trees of this species, reads:—white to the ground, bark peels off in short flakes, buds often have double operculum.

Small trees about twenty feet high of various species of Grevillea were fairly common throughout. *G. polystachya* with beautiful creamy flowers, and *G. chrysodendron* with charming yellowish-red flowers were the most conspicuous. *G. gibbosa* was first noticed near Biboohra after which it was seen the whole way. It is known as Beef Tree or Beefwood owing to the appearance of its timber, which is prettily marked with medullary rays, a common feature of the timbers of the Natural Order Proteaceæ. For a species of Grevillea its orbicular, gibbous fruits are somewhat remarkable for their shape and size, the longer axis sometimes measuring as much as two and a quarter inches. This species was not flowering in August but was conspicuous by its silvery looking leaves.

Casuarina suberosa (Black Oak) and *C. torulosa* (Forest Oak), were not noticed for more than twenty miles west of Kuranda. These are both well known coastal species, the former extending south to Tasmania, while the latter does not occur much to the south of Sydney.

C. Cunninghamiana (River Oak) was noticed on many of the large streams from Kuranda to Alma-den, including the head waters of the Walsh River, a tributary of the Mitchell, but was not seen on the lower Gilbert or lower Flinders. Although this species ranges from North Queensland southerly to the Murrumbidgee River, and occurs on fresh water streams on both sides of the Main Divide, it appears to have limitations in regard to its powers of resisting extremes of cold and salinity. Thus, although it occurs on the upper portions of all the main western rivers of New South Wales from the Murrumbidgee northwards, it has not been recorded from Victoria, nor does it extend down the rivers to the Murray, as though it prefers the swiftly running to the sluggish streams. It is rarely found at elevations exceeding 3,000 feet above sea level. It is of interest to note that its distribution in North Queensland seems to be regulated by the same factors which govern its occurrence in the south, and it appears throughout to avoid the lower portions of the western streams. As previously suggested, its inability to descend the rivers to the sluggish portions may be owing to the presence there of saline conditions which often prevail in times of drought, and which this species always shuns.[1]

In 1845 Leichhardt noted its absence from the lower portions of the Gilbert, Norman, Flinders, Leichhardt and Albert Rivers, and when on the Nicholson, near the western border of Queensland, he wrote:—"We crossed a creek in which we recognised a Casuarina, which tree we had not seen since we left the Mitchell."[2] He does not mention what species of Casuarina was growing on the Nicholson.

The River Oak affords a splendid object lesson in the limitations which may sometimes attend the distribution

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[1] Notes on the Botany of the Interior of New South Wales," Part V. By R. H. Cambage. Proc. Linn. Soc. N.S. Wales, Vol. xxvi, (1901) p. 685.

[2] Journal of an Overland Expedition in Australia, p. 368.

of a plant, for here we have a species which flourishes on the banks of fresh water streams, and extends throughout the greater portion of Eastern Australia, north and south, but is unable to follow the streams for any great distance across the continent to the westward. Its great desidratum appears to be perfectly fresh water, and this is usually best obtained where the water is in motion.

Casuarina Luehmanni (Bull Oak) occurs between Kambul and Biboohra, just north of latitude 17°, so that this record places its known northerly range well into the tropics. It is now known to extend from Biboohra in the north to south-western Victoria and south-eastern South Australia near Serviceton in the south. It is remarkable that a species with such an extensive range should show so little variation in habit, for it may be mentioned that the general appearance of the Bull Oak trees near Kambul is so similar to those of New South Wales and Victoria, that the species was identified from the train window. The identification, however, has since been corroborated by the receipt of specimens kindly sent by Miss L. Martin of Biboohra, and which show the characteristic flat cones with seeds arranged in three whorls.

ALMA-DEN.

Parts of two days were spent in examining and collecting plants within a radius of one or two miles of Alma-den, which is situated 121 miles by rail westerly from Cairns, and 18 miles short of Chillagoe.

The geological formation of the area examined is granite containing about 68 to 70° silica, and producing an open forest vegetation. The locality is about 1,600 feet above sea level, and is to some extent comparable with the lower western slopes of northern New South Wales. The rainfall, which is somewhere in the vicinity of 35 inches annually, is confined chiefly to the period between December and

April, and this latter condition applies to practically the whole of northern Queensland, so that by the month of August the country away form the watercourses is getting decidedly dry. Botanists who have had experience in collecting in this class of country well know that the season for the flowering and fruiting of a plant is short. The result is that the visitor often finds a difficulty in identifying plants owing to the absence of both flowers and fruits. It will also be understood that small plants, including grasses, are likely to be overlooked in the dry season.

The following is a list of plants noted around Alma-den. Authors' names are not repeated where they have been previously used for the same plant:—

BIXACEÆ: *Cochlospermum Gillivræi* Benth., (Native Cotton).

PITTOSPORACEÆ: *Bursaria incana* Lindl., (30 feet high, 10 inches in diameter, spineless).

STERCULIACEÆ: *Sterculia Bidwilli* Hook.

TILIACEÆ: *Grewia polygama* Roxb., (a medicinal plant).

BURSERACEÆ: *Canarium australasicum* F.v.M., (an endemic species 20 to 30 feet high with hard rough bark, and belonging to an Order widely distributed throughout the tropics).

CELASTRINEÆ: *Celastrus Cunninghamii* F.v.M.

RHAMNACEÆ: *Alphitonia excelsa.*

SAPINDACEÆ: *Dodonæa physocarpa* F.v.M., (Hopbush, with pinnate leaves).

LEGUMINOSÆ: *Desmodium umbellatum* DC., ? (a small tree), *Erythrina vespertilio* Benth., (a Coral-tree), *Acacia hemignosta* F.v.M., *A. leptostachya* Benth.,? *A. holcocarpa* Benth., *A. plectocarpa* A. Cunn., *A. holosericea* A. Cunn., *A. Bidwilli* Benth.

MYRTACEÆ: *Calythrix leptophylla* Benth., (6 feet high), *Melaleuca leucadendron* Linn.? (Paper-barked Tea tree, 20 feet high, flowering in August), *M. Cunninghamii* Schauer ? (20 feet

high, bark papery to almost fibrous, flowering just over in August), *M. saligna* Schauer, (Willow Tea-tree 60 to 70 feet high, pendulous, papery bark, growing on the banks of streams), *M. genistifolia* Sm. (12 to 20 feet high, 10 inches in diameter, bark hard and firm, growing in clumps, flowering in August 1913), *Eucalyptus leptophleba* (Box), *E. crebra* (Narrow-leaved Ironbark), *E. miniata*, *E. rostrata* (River Red Gum), *E. clavigera* A. Cunn., (Apple Gum), *E. papuana*, (*E. tesselaris* var. *Dallachiana* Benth., Cabbage Gum), *E. peltata* Benth., (Yellow Jack), *E. dichromophloia* ? (No. 3909 and 4160, Red Bloodwood), *E. terminalis* F.v.M. ? (Nos. 3906 and 3908, Bloodwood), *Careya australis* (Cockatoo Apple).

UMBELLIFERÆ: *Didiscus hemicarpus* F.v.M. ? (20 inches high).

RUBIACEÆ: *Gardenia ochreata* F.v.M. ? (small tree with rugose bark, fruits ovoid, 2 inches by 1 inch), *G. sp.* (10 to 15 feet high, fruits almost globular, ¾ inch diameter).

STYLIDIEÆ: *Stylidium Floodii* F.v.M. ? (6 inches high).

CAMPANULACEÆ: *Wahlenbergia gracilis* DC., (Blue Bell).

APOCYNACEÆ: *Alyxia thyrsiflora* Benth., (little shrubs of 4 or 5 feet growing in groups in rocky situations, flowering in August).

PROTEACEÆ: *Persoonia falcata*, *Grevillea chrysodendron* (with beautiful reddish-yellow flowers in August), *G. polystachya*, *G. mimosoides* R. Br. ? (10 to 15 feet), *G. gibbosa* (Beef Tree, 30 feet high), *Hakea Persiehana* F.v.M., (with terete leaves up to 8 inches long and 1 mm. in diameter, and fruits 4·5 cm. long by 3 cm. broad).

THYMELACEÆ: *Pimelea sp.* (from 1 to 2 feet high, densely clothed with silvery, silky hairs, and may be an undescribed species).

SANTALACEÆ: *Santalum lanceolatum* R. Br.

EUPHORBIACEÆ: *Petalostigma quadriloculare* F.v.M., (Quinine, 30 feet high), *Mallotus sp.* (a tree about 25 feet high with hard rough bark).

CONIFERÆ: *Callitris columnellaris* F.v.M. (Pine, 20 feet high).

ORCHIDACEÆ: *Cymbidium sp.*

HÆMODORACEÆ: *Hæmodorum planifolium* R. Br. ? (Red-root).

PANDANACEÆ: *Pandanus aquaticus.* ?

Trees of *Cochlospermum Gillivræi* (Native Cotton) grow to a height of twenty to twenty-five feet, and appear to prefer rocky elevations. They are deciduous, and were leafless in August or while in bloom. They become covered with bright yellow flowers about two inches across, which give the trees a very attractive appearance. The presence of a woolly substance inside the large pod-like seed vessels has caused the plant to be often referred to as Native Cotton.

Sterculia Bidwilli was seen occupying rocky granite elevations with the last named species, the trees being about fifteen feet high and deciduous. In August, trees of this species were leafless, and coming into bloom, the flowers being more than an inch long, and nearly an inch across, bell-shaped and red.

Grewia polygama grows as a small shrub and extends to the East Indies. It belongs to a genus widely spread over the tropics. The small two-lobed fruits of this species are sometimes called Jelly-boys in Queensland, and in addition to being regarded by some people as edible, are considered to have distinct medicinal qualities especially in cases of dysentery. Leichhardt records that in June 1845 when below the junction of the Lynd and Mitchell Rivers, or about one hundred and twenty miles north-west of Almaden, he used the seeds of a species of Grewia in making a beverage, and writes:—"I gathered as many as I could, and boiled them for about an hour, the beverage which they produced was at all events the best we had tasted on our expedition." (*Op. cit.*, p. 295.)

Erythrina vespertilio, a Coral tree, was noticed on rocky hills. These trees, which were about twenty feet high,

with prickly stems, were leafless in August, but fairly well covered with red flowers. It is a common Queensland species, and also occurs in north-western New South Wales.

Acacia hemignosta grows into small trees about fifteen feet high. It has flat pods, and pale or slightly glaucous leaves which, when seen growing, somewhat resemble those of *Santalum lanceolatum*. This Acacia does not appear to have been previously recorded for Queensland, although Bentham mentions its occurrence in North Australia, and includes in the localities the Albert and Gilbert Rivers, both of which, however, are in Queensland. It is fairly common north of the Cloncurry district.

A. holosericea was seen up to about fifteen feet high, with large silvery three-nerved phyllodes, and spiral pods with very small seeds. This is one of the few Australian Acacias which crosses to Papua.[1]

A. Bidwilli is one of the bipinnate leaved Acacias and was noticed with and without spines, and growing to a height of about thirty feet. Many of the trees had a distinctly corky bark.

Eucalyptus crebra, (No. 3905 Narrow-leaved Ironbark), is a common tree around Alma-den, and has been very largely used for the mines at Chillagoe nearly twenty miles away. In leaves, bark and timber, it resembles the typical New South Wales form, but around Alma-den the fruits are larger, 7 mm. in diameter, nearly hemispherical, and have a distinct rim as well as somewhat exserted valves; the pedicels are also finer, in fact, the fruits are so different from the type as to make it desirable that a careful examination should be made of the flowers, which were not seen. These trees are being further investigated.

[1] Australian Vegetation, by J. H. Maiden, F.L.S. Federal Handbook, p. 179.

Eucalyptus rostrata (River Red Gum) is a common tree on the banks of many of the rivers and large creeks of North Queensland. It is often associated with *Casuarina Cunninghamiana* (River Oak), and while usually not able to ascend so far, can descend much further down the streams, and this attribute or quality has enabled it to cross the continent from north to south and from east to west. It does not occur in Tasmania and avoids the cold portions of the mainland.

The tree identified as *Eucalyptus clavigera* (No. 4159) is what eastern New South Wales bushmen would be likely to call Apple-gum. Its leaves as seen around Alma-den are sessile, often cordate and opposite, both in the primary and adult forms, and ovate, the hispid midrib and lateral veins standing out in relief on both sides of the leaf, which is excessively scabrous or harsh to the touch. In general appearance the leaves closely resemble those of *Angophora subvelutina* F.v.M., (Apple Tree) and some of the juvenile forms measured 8 by 5 inches, and it is known that these dimensions are exceeded in other localities. The bark on the main portion of the trunk and branches is white and smooth, while that at the base and for a height of 8 or 10 feet, is tessellated in a manner very similar to that of *Eucalyptus tesselaris* F.v.M., the Moreton Bay Ash of Queensland, or Carbeen of north-western New South Wales. (Plate LVII, fig. 1). The trees reach a height of fifty feet with a diameter of two to three feet, and if dead, will burn right away after being lighted, a character common also among the Angophoras. Neither buds nor flowers were seen, but some empty seed vessels 1·2 cm. long and 9 mm. in diameter were procured having pedicels up to 2·2 cm. long.

There seems no doubt that these trees belong to the same species as those referred to by Leichhardt as Apple-gum, and which were first seen by him near the head of the Lynd

River, and afterwards until after he had crossed the Roper River in the Northern Territory. His first entry reads :—"Another Eucalyptus with a scaly butt like the Moreton Bay Ash, but with a smooth upper trunk and cordate ovate leaves, which was also new to me; we called it Apple-gum." (*Op. cit.*, p. 264, 304, 325, 353, 394, 464, 473).

This Apple-gum was seen by me at various points between Alma-den and Normanton, and again in the Cloncurry River district.

Another Eucalypt of considerable interest seen around Alma-den was *E. papuana* F.v.M., (*E. tesselaris* var. *Dallachiana* Benth., or *E. clavigera* var. *Dallachiana* Maiden).[1] A feature of these trees is that their leaves are often shiny and twisted, or crinkled, those on small saplings being usually very large, sometimes measuring eleven by five and a half inches, but in all cases smooth and petiolate. The bark on the main portion of the trunk is smooth and white, but in this locality there is sometimes a little roughness on the butt for a height of six or eight feet, but in many cases the bark is white to the ground, and turns brown before peeling off. (Plate LVII, fig. 2.) The timber is a very dark brown, and the fruits seem intermediate between those of *E. tesselaris* and *E. clavigera*, being up to 1 cm. long, by 7 mm. in diameter, with pedicels of 3 to 4 mm. Neither buds nor flowers were obtained. These trees appeared to be quite distinct from those of *E. clavigera* growing near. Trees of *E. papuana* were seen intermittently from Alma-den to Normanton, on the Gilbert, Flinders, Corella and Cloncurry Rivers, and around Barcaldine, and were in most cases smooth and white to the ground and known as Cabbage Gum.

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[1] "Notes on Eucalyptus," by J. H. Maiden, F.L.S., Proc. Roy. Soc. N.S. Wales, Vol. XLVII, (1913), p. 77; also Vol. XLIX, (1915), p. 330.

In the river country the Cabbage Gum is nearly always white to the ground, and is a very shapely and umbrageous tree, about forty to fifty feet high, and undoubtedly seems to be worthy of specific rank. I was informed that in the lower Flinders district these trees withstood the drought of 1902 better than any other Eucalypt.

It seems likely that the trees mentioned by Leichhardt (*op. cit.*, p. 325, 351 and 355) as White-gum, and Drooping White-gum are of this species.

Eucalyptus peltata is known around Alma-den as Yellow Jack, from the yellowish colour of the scaly bark which is of much the same texture as that of the Bloodwood group, though perhaps a little more flaky. This rough scaly bark extends to the branchlets, the tips of which are angular, glabrous and yellowish. The timber is pale towards the outside of the tree, but dark brown near the centre. The fruits are slightly urceolate and the sessile buds are angular in dried specimens. The only peltate leaves seen were amongst the ovate, scabrous, "sucker" foliage. The adult leaves examined are glabrous and lanceolate, with a yellowish midrib, and are five to six inches long, and one quarter of an inch to one inch broad. The "sucker" stems are hispid.

This species occurs plentifully between Einasleigh and Wirra Wirra, near Forsayth. Exactly similar trees, as regards appearance and habit, were seen from the train, in the Desert near Jericho, to the east of Barcaldine, but as these trees were not examined, their identification is doubtful, though it is understood they are known as *Eucalyptus Leichhardtii* Bailey.

The species of Eucalyptus (Nos. 3909 and 4160), which I have referred to in these notes as Red Bloodwood, because of the reddish, rusty colour of its flaky bark, has so far not been definitely identified, though it is a common tree in

the siliceous soils of the forests of tropical Queensland, and is probably *E. dichromophloia* F.v.M. It usually occurs on ridges and hill slopes but seems to avoid rich alluvial flats, though it was noticed on some gravelly low land. It has a somewhat flaky reddish bark all over the trunk, while the branches are usually smooth and often pale red. The fruits as examined over a very wide area, are urceolate, from about 1·2 to 1·5 cm. long, by 9 mm. to 1·2 cm. in diameter, with thin rims slightly expanded at the orifice to about 5 to 7 mm. across, and slender pedicels of about 4 to 5 mm. long. The seeds terminate in a wing or samara 4 to 5 mm. long, by 2 to 3 mm. broad. The timber is reddish-brown. Neither flowers nor buds were procured.

The species was seen at intervals most of the way from Mareeba to Normanton where it is growing near the artesian bore in the town; also on the Cretaceous sandstone ridges near Donors Hills on the road to Cloncurry. Specimens of this species were collected at Prairie, east of Hughenden, and at Bogantungan, about 220 miles west of Rockhampton: The species showed practically no variation over the whole of the area in which it was examined, and in some respects agrees with the description of *E. terminalis* F.v.M., except that the fruits of the latter are described as slightly longer and less urceolate. It is quite distinct from *E. corymbosa*, and appears to be the species referred to by P. A. O'Shanesy[1] and J. E. Tenison-Woods as *E. terminalis*.[2]

There is apparently no question but that this Red Bloodwood is the species referred to by Leichhardt as Rusty-gum. On page 21 (Overland Expedition) he writes that when on clayey sandstone country on Dogwood Creek, south of the

[1] "Flora of Queensland," by P. A. O'Shanesy, F.L.S., (1880).

[2] "Botanical Notes on Queensland," by Rev. J. E. Tenison-Woods. F.G.S. Proc. Linn. Soc. N.S. Wales, Vol. VII, (1882), p. 333.

Dawson River, he found "A new gum-tree, with a rusty coloured scaly bark, the texture of which, as well as the seed-vessel and the leaf, resembled bloodwood, but specifically different." He again refers to it when on Stephen's Creek (p. 139) and writes:—"A rather stunted rusty gum grew plentifully on the sandstone ridges." It was again noted (p. 195) near the Cape and Suttor Rivers, and (p. 304) below the junction of the Lynd and Mitchell Rivers, also (p. 355) near the Leichhardt River, and "on sandstone ranges" (p. 460) beyond the Roper River, and last (p. 526) near Port Essington.

A second rather larger Bloodwood tree, (*E. terminalis?* Nos. 3906 and 3908) occurs at Alma-den, which I have referred to in these notes simply as Bloodwood, and it was noticed over practically the same range as the Red Bloodwood, but with this difference in location that, while the latter favoured the elevated land the former was more often found on the fairly siliceous flats and in the valleys. These two species are quite distinct and can be easily distinguished when seen from coach or train. At certain stages of growth the fruits might be confused with those of the Red Bloodwood, and as the leaves are very similar there seems a possibility that both these species have been placed, in part, under *E. terminalis.*

In its bark and general appearance the Bloodwood somewhat resembles *E. corymbosa*, the well known coast Bloodwood, but is specifically distinct, while it also shows affinities with *E. Abergiana* F.v.M. Its timber is redder than that of the Red-barked Bloodwood, and is regarded as the best of the bloodwood timbers around Alma-den. The fruits vary from urceolate to almost cylindrical with very little contraction at the neck, and the shape changes with the development of the seed vessels. At the time the flowers fall, the very young fruits are sometimes obconical,

and their shape is not then in the least suggestive of the mature form. The fruits seen range from 1·6 cm. to 2·4 cm. in length, the diameter being from about 1·1 to 1·2 cm., and the width across the usually thin rim 6 to 7 mm., the capsule sunk. Some old buds which had perished and remained on the tree were about 7 mm. in diameter.

This is the tree referred to by Leichhardt as Bloodwood near the junction of the Lynd and Mitchell Rivers. He writes:—"The bergue was covered with fine bloodwood trees," (p. 292), and "the bloodwood, the apple-gum, the box, and the flooded-gum, grew along the bergue of the river," (p. 296). He also mentions that the bloodwood was in blossom in June (p. 297). He refers to the tree again (p. 370), when on the Nicholson, and on three subsequent occasions, (p. 394, 473, and 529) the last being when near Port Essington.

This species was in flower at several places, including Frewhurst, the lower Flinders, and near Cloncurry, in August 1913.

Trees which in habit appear to belong to the same species were flowering in August at Prairie, east of Hughenden (No. 3958), but the fruits are larger, being as much as 2·7 cm. long with a diameter up to 2 cm. and the rim is thick, the orifice measuring from about 1 to 1·5 cm. across, the capsule sunk. The flowering period for *E. corymbosa* is February and March.

Petalostigma quadriloculare is known in North Queensland as Quinine, from the exceedingly bitter taste of the numerous small yellow fruits, and it has a very wide distribution. It grows into small trees from fifteen to thirty feet high. Leichhardt refers to this tree throughout his expedition and calls it the "Severn Tree," after the Severn River in northern New South Wales where he first saw it. When near the Norman River he wrote:—"The emu here

feeds on the fruit of the little Severn tree, which is so excessively bitter, as to impart its quality to the meat."

Clumps of several acres of little trees called Quinine, with elliptical leaves, and slightly resembling orange trees, were seen towards Croydon, and it was pointed out from the coach, that the western side of the stem nearly always shows a strip of dead wood. There was no opportunity of definitely identifying the species or investigating the statement which, however, was seen to be correct in many instances.

ALMA-DEN TO FORSAYTH.

The distance from Alma-den to Forsayth (Charlestown) is 143 miles south-westerly, and as the journey was made by train only very limited collecting could be done during the wait at a few of the platforms, and the list of plants identified is small. At forty-three miles the Lynd River was crossed. This stream, which flows north-westerly, was discovered and named by Leichhardt in May 1845, and was followed by him to its junction with the Mitchell, which he also discovered and named. For the first twenty miles the flora is much the same as that seen around Alma-den, but towards the valley of the Lynd, fresh species gradually appear, though there is no decided change in the vegetation the whole way to Forsayth.

The geological formation passed over consisted largely of granite during the early portion of the journey, but beyond the forty-six mile-post, sheets of basalt were encountered for about twenty-five miles, examples of amygdaloidal structure being common near the Mount Surprise railway station, (1,487 feet). From about the seventy-two mile-post onwards the country alternates between granite, slate and some sandstone near Wirra Wirra.

The following is the list of plants noted after passing the twenty mile-post:—

RHAMNACEÆ: *Alphitonia excelsa.*

LEGUMINOSÆ: *Erythrina vespertilio, Bauhinia Hookeri* F.v.M., (near Forsayth, with large white flowers), *Erythrophlœum Laboucherii* F.v.M. (Ironwood), *Acacia doratoxylon* A. Cunn.? (Lancewood), *A. holosericea, A. Sutherlandi* F.v.M.? (Cork-tree).

COMBRETACEÆ: *Terminalia platyptera* F.v.M., (at 1426 feet near Lyndbrook platform, with two-winged pubescent fruit, wood yellowish, trees 20 to 25 feet high.)

MYRTACEÆ: *Melaleuca leucadendron, ? M. genistifolia, Eucalyptus melanophloia* (Silver-leaved Ironbark), *E. leptophleba* (Box), *E. sp.* (No. 4162, White Box), *E. crebra* (Narrow-leaved Ironbark), *E. miniata* (Tobacco-Pipe Gum or Woollybutt), *E. rostrata* (River Red-gum), *E. clavigera* (Apple gum), *E. tesselaris ?* (Moreton Bay Ash), *E. papuana (E. tesselaris* var. *Dallachiana,* Cabbage Gum), *E. peltata* (Yellow Jack), *E. dichromophloia ?* (Red Bloodwood), *E. terminalis ?* (Bloodwood), *E. tetrodonta* F.v.M. (Messmate or Stringy-bark), *E. Brownii* Maiden and Cambage (Narrow-leaved Box), *Careya australis.*

RUBIACEÆ: *Gardenia edulis* F.v.M. (Bread-fruit tree of Leichhardt).

MYOPORACEÆ: *Eremophila Mitchelli* Benth. ? (Budtha or Budda of New South Wales, sometimes called Sandalwood).

PROTEACEÆ: *Persoonia falcata, Grevillea chrysodendron, G. striata* R. Br., (up to 40 feet high), *G. gibbosa* (Beef-tree), *Hakea lorea* R. Br.,? (near Forsayth), *H. arborescens* R. Br., (near Mount Surprise).

EUPHORBIACEÆ: *Petalostigma quadriloculare* (Quinine).

CASUARINACEÆ: *Casuarina Cunninghamiana* (River Oak on Lynd River and various other streams), *C. Cambagei* R. T. Baker ? (Belah).

CONIFERÆ: *Callitris sp.* (Pine).

ORCHIDACEÆ: *Cymbidium sp.* (growing in the hollow portions of various trees).

JUNCACEÆ: *Xanthorrhœa sp.* (Grass-tree, caudex two feet).

PANDANACEÆ: *Pandanus aquaticus*?

The trees provisionally identified as *Acacia doratoxylon* (No. 4106) are locally known as Lancewood, and were noticed from near Einasleigh and Wirra Wirra onwards to Croydon. They seem to avoid the basic formations and were seen chiefly on granite or sandstone, and in some cases reached a height of quite forty feet, though they were commonly from twenty to thirty feet. In western New South Wales trees of this species, which are known as Currawong, are usually confined to ridges, but the Lancewood, though common on the elevated land, often grows well down on the slopes where it attains its largest size.

After the one hundred and fifteenth mile-post was passed, an undescribed species of Eucalyptus appeared, (*E. Brownii* Maiden and Cambage, these Proceedings, 1913, p. 215). The note made in the train conveys a general description of the tree, and reads:—"A narrow-leaved Box, seems distinct species, rough bark on branches, green leaves." These trees were growing on a contorted micaceous slate formation showing quartz, but they continued intermittently to Wirra Wirra where the rock is sandstone, possibly Upper Cretaceous. This Box tree averages about forty feet high, with small fruits, and according to Mr. Thomas Keller of Wirra Wirra has dark red timber.

Eucalyptus tetrodonta was first noticed between the twenty-second and twenty-fourth mile-posts from Alma-den and again towards the fifty-first mile-post. It was subsequently seen at various points along the Gilbert River, at

the changing station on the Little River, and around Normanton.

This species, which was the only Eucalypt met with belonging to the subseries Eudesmieæ, is a very interesting one, for in addition to being one of the few having calyx teeth, like the Angophoras, it is apparently the only stringybark to be found in Northern Australia, excepting in the extreme east. It is known both as Messmate and Stringybark, and its bark is decidedly fibrous, the timber being reddish-brown.

In New South Wales the only Stringybark which extends to the western districts is *E. macrorrhyncha* F.v.M., and as it approaches its western limit and reaches the drier country it becomes confined to the elevated land, but does not penetrate so far inland as Nymagee, Nyngan or Moree.

The "sucker" leaves of *E. tetrodonta* are opposite or alternate, ovate to ovate-lanceolate, up to seven inches long by three to four inches broad, with petioles of half to three-quarters of an inch long, the lateral veins being arranged at an angle of about 60° with the midrib, the intramarginal vein being close to the edge, the midrib prominent on the upper side of the leaf, the young leaves often reddish. The trees, which are erect, have an average height of about forty feet with a diameter of about one foot, and prefer siliceous soil.

This is the species referred to by Leichhardt as Stringybark, and noted at various points from the upper Lynd right to the settlement at Port Essington.

Between the sixty-ninth and seventy-first mile-posts several trees were seen which exactly resemble *Casuarina Cambagei* (Belah, a species regarded as *C. lepidophloia* by Mr. Maiden), but as it was impossible to obtain specimens for verification, the identification may not be accurate.

FORSAYTH TO GEORGETOWN, CROYDON AND NORMANTON.

The journey from Forsayth (Charlestown) to Croydon was made by coach, the distance being one hundred and thirty-five miles, while from Croydon to Normanton, a distance of ninety-four miles, the train was used. The country falls gradually most of the way, the height of the railway at Forsayth being 1,326 feet, at Croydon three hundred and sixty-one feet, while at Normanton it is only thirty-two feet above sea level.

From Forsayth to Georgetown on the Etheridge River, a distance northerly of twenty-five miles, the geological formation is chiefly granite and porphyry. From Georgetown to Croydon is westerly, one hundred and ten miles, the formation for nearly thirty miles being mostly granitic. Beyond this point the Gilbert River is reached and followed for more than thirty miles, the country being largely made up of alluvium with the river bed full of sand. This river was discovered and named by Leichhardt on 12th July, 1845, after the naturalist of his party, who was murdered by the natives. Before Croydon is reached small escarpments of Upper Cretaceous sandstone may be seen on both sides, while at Croydon the granitic and porphyritic rocks reappear. From Croydon to Normanton no rocks are visible from the train and the soil is chiefly of a sandy nature.

The vegetation for the most part from Forsayth to Normanton is open forest, largely made up of Eucalyptus, shady Terminalias, bright flowered Bauhinias and Grevilleas, and clumps of various Acacias, the lagoons near the Gilbert and Norman Rivers being dotted with charming pale blue and white Water Lilies *(Nymphæa sp.)*, while the banks of the large streams are decorated with the beautiful drooping Willow Teatree, *(Melaleuca saligna)*.

Between Forsayth and Normanton the following plants were noticed:—

NYMPHÆACEÆ: *Nymphæa sp.* (Water Lilies on various lagoons).

BIXACEÆ: *Cochlospermum Gillivræi* (Native Cotton).

STERCULIACEÆ: *Sterculia Bidwilli.*

TILIACEÆ: *Grewia polygama* (Jelly Boys).

RHAMNACEÆ: *Zizyphus jujuba* Lam., (Jujube), *Alphitonia excelsa.*

SAPINDACEÆ: *Atalaya hemiglauca* F.v.M., (Whitewood).

LEGUMINOSÆ: *Crotalaria Mitchelli* Benth.,? (on Gilbert River), *Erythrina vespertilio,* (a Coral tree), *Bauhinia Carronii* F.v.M., *B. Hookeri, Erythrophlœum Laboucherii* (Ironwood), *Acacia galioides* Benth., *A. hemignosta, A. sericata;* A. Cunn., *A. doratoxylon?* (Lancewood), *A. delibrata* A. Cunn.? *A. torulosa* Benth., *A. julifera* Benth.? (or *A. Solandri* Benth.?), *A. holcocarpa, A. plectocarpa, A. holosericea, A. Bidwilli.*

COMBRETACEÆ: *Terminalia melanocarpa* F.v.M., *T. platyphylla* F.v.M.

MYRTACEÆ: *Calythrix microphylla* A. Cunn., (2 – 3 feet high, with beautiful pink flowers, on Upper Cretaceous Sandstone two miles north of Croydon), *Melaleuca leucadendron* var. *viridiflora* Soland., (No. 3929 with leaves up to $2\frac{3}{4}$ inches long, and venation similar to that of *M. Cunninghamii* No. 3922, 20 feet high, at Croydon), *M. saligna, M. Cunninghamii* Schau., *M. genistifolia, M. symphyocarpa* F.v.M., *Eucalyptus gracilis* F.v.M.,? *E. pruinosa* Schau. (Silver-leaved Box), *E. melanophloia, E. crebra* (seen only between Forsayth and Georgetown), *E. sp.,* (No. 4162, a White Box), *E. miniata, E. rostrata, E. clavigera, E. papuana* (Cabbage Gum), *E. setosa* Schau., *E. terminalis?* (Bloodwood), *E. dichromophloia?* (Red Bloodwood), *E. tetrodonta* (Messmate or Stringybark), *Careya australis.*

LORANTHACEÆ: *Loranthus longiflorus* Desr., (Mistletoe, yellow flowers, with *Melaleuca saligna* as host, Etheridge River), *L. longifolius* Hook.? (red flowers, with *Melaleuca saligna* as host, Etheridge River)

RUBIACEÆ: *Gardenia edulis* (Bread-fruit tree).

APOCYNACEÆ: *Vinca rosea* Linn. var. *alba* (naturalised).

ASCLEPIADACEÆ: *Cryptostegia grandiflora* R. Br., (a naturalised straggling rubber plant from Tropical Africa, having a pair of remarkable looking triangular fruits pointing in opposite directions, about four to five inches long, resembling horns, and containing a silky fibre attached to the seeds. Seen only at Georgetown. It is said that this plant is not eaten by goats). *Sarcostemma australe* R. Br., (a thin leafless vine, the seeds attached to silky tufts of hairs).

BIGNONIACEÆ: *Spathodea alternifolia* R. Br., (a straggling shrub, the flat pod-like capsule up to eighteen inches long and half an inch wide. Seen only near Normanton).

MYOPORACEÆ: *Eremophila longifolia* F.v.M. ?

LABIATÆ: *Anisomeles salvifolia* R. Br.? (near Gilbert River).

PROTEACEÆ: *Grevillea chrysodendron*, *G. striata*, *G. gibbosa*, *Hakea arborescens* (ten feet high, at Normanton), *H. Persiehana.*

EUPHORBIACEÆ: *Petalostigma quadriloculare.*

URTICACEÆ: *Ficus glomerata* Willd, (Red Fig).

ORCHIDACEÆ: *Cymbidium sp.*

PANDANACEÆ: *Pandanus aquaticus.?*

GRAMINEÆ: *Triodia irritans* R. Br., (Spinifex or Porcupine grass), *Ectrosia Schultzii* Benth., (a grass, at Croydon).

Zizyphus jujuba, a well known little tree in tropical Asia, and occurring also in tropical Africa, is common in the Croydon district and other parts of Queensland, being known as the Jujube tree. The plants average about ten to fifteen feet high, generally with stipular prickles on the stem and branches, and the fruits are edible, having a flavour resembling that of an apple scarcely ripe.

Atalaya hemiglauca was first noticed near Georgetown, on a granite formation not highly siliceous, and was seen

afterwards at various points near the Flinders and Cloncurry Rivers and to the southward near Winton and Longreach. It is known to extend as far south as Nyngan. This is the common Whitewood, a drought-resisting fodder tree of the Bourke country, and the fruits are somewhat remarkable for the samaræ or wings. The presence of this and other species mentioned, of north-western New South Wales trees around the Gulf of Carpentaria and over the intervening area, is evidence of a similarity of climatic conditions over this thousand miles of country.

Bauhinia Carronii and *B. Hookeri*, the former with bright red, and the latter with beautiful white flowers were noticed at various points. They seem to be usually known as Bohemia or Bohemew trees, the name evidently being a corruption of Bauhinia. At Boomarra station near the Cloncurry, the native name of *B. Carronii* was given me as "Bigunny," being practically the same as that recorded for the same species by Mr. Edward Palmer, ("Pegunny").[1] The flowers of both species are rich in honey, and at Georgetown a tree of *B. Carronii*, which at that period had a scanty supply of leaves, but was covered with scarlet flowers, was noticed to be full of birds which were busily engaged extracting honey, and at the same time carolling in a most delightful manner, as so many Australian birds can do, and filling the air with sounds of gladness. The leaves of these trees are very prettily arranged as pairs of leaflets somewhat ovate in shape, and in their disposition resemble the wings of a butterfly when at rest. The leaflets close up at night.

The genus is one of considerable interest and extends over the tropical regions of the world. *B. Carronii* is recorded as far south as from the extreme north-west por-

[1] "On Plants used by the Natives of North Queensland, Flinders and Mitchell Rivers, for Food, Medicine, etc." This Journal, Vol. XVII, (1883) p. 95.

tion of New South Wales. When writing of the genus, Bentham states:—"Leaflets either two distinct from the base, or (in the majority of species not Australian) united into an entire or two-lobed leaf, with five to eleven digitate nerves." He also says:—"The following Australian species (3), all endemic, with one or two nearly allied Asiatic ones, form a small group, with the two leaflets quite distinct."[1]

In this connection it is of interest to note that although most of the Australian species have their leaflets distinct from the base, yet the primary leaf of a seedling recently raised from the seed of an undetermined Bauhinia, collected near Barcaldine in Central Queensland by Sir William Cullen, was simple and bi-lobed, the leaflets being united for the greater portion of their length. The leaflets of the second and all subsequent leaves were distinct. The fact of this primary leaf being bi-lobed goes to show that this is an ancestral character, and the development of separate leaflets is another of the various forms of specialising resorted to by Australian plants.

B. Hawkesiana Bailey, is a Queensland species with the leaflets united, described since Bentham wrote the Flora Australiensis.

Lubbock records a seedling of *B. Carronii* as having the primary and all subsequent leaves divided into two distinct leaflets.[2]

Erythrophlœum Laboucherii, commonly called Ironwood around the Gulf of Carpentaria, is the "Leguminous Ironbark" of Leichhardt. The wood of this species is exceedingly hard, and it is a well known fact that it was used by the natives for the making of weapons, examples of which are now in many collections. In August 1913 a native at

[1] "Flora Australiensis," Vol. II, p. 295.

[2] "A Contribution to our Knowledge of Seedlings," by Sir John Lubbock, Vol. I, p. 464.

Croydon was seen with a sword upwards of three feet long and quite three inches broad, which it was understood was made from this species.

Bentham gives the length of the flower-spike of this species as from one to three inches, but spikes were found at Croydon measuring up to four and three-quarter inches long.

Acacia galioides was found on a rocky hill of Upper Cretaceous sandstone about two miles north of Croydon, a fossil of *Maccoyella mariæburnensis* collected close by, and which helps to determine the age of the rocks, having been identified by Mr. W. S. Dun. Only a few plants were seen and these were about two feet high. This was the only Acacia noticed belonging to the series Brunioideæ, a character of which section is that the phyllodia are verticillate.

A. sericata was passed between the Gilbert River and Croydon, the only specimen obtained being snatched from a branch as the coach went past. The little trees ranged from about ten to fifteen feet high. The large flat pod is made somewhat remarkable by being bordered with a pronounced narrow edging.

The wattle provisionally identified as *A. delibrata* ? (No. 3898) was growing on the banks of the Etheridge River at Georgetown. The flowering was nearly over in August and the young pods just formed were narrow and very viscid or almost glutinous. In the absence of mature pods the determination is doubtful.

A. torulosa (No. 4107) is a common species near Croydon and forms a natural avenue along the road for about a mile. The flowering is over towards the end of August.

The plant identified as *A. julifera ?* or *A. Solandri ?* (No. 4109) was found near Normanton. The very young pods were narrow and spirally twisted into loose coils.

Terminalia melanocarpa and *T. platyphylla* (Plate LVIII, fig. 2) were seen near the Etheridge and Gilbert Rivers, and are beautiful shade trees somewhat resembling an English mulberry, but around the Gulf or Carpentaria they are often known as Pear trees.

One of the most beautiful and conspicuous of the large trees along the banks of streams in tropical Queensland is *Melaleuca saligna*. It occurs at elevations of at least 1600 feet above sea level as at Alma-den, which is on a tributary of the Mitchell River about 250 miles from its mouth, and will descend practically to sea level. Two of the common river trees of Eastern Australia are *Eucalyptus rostrata* (not confined to the east) and *Casuarina Cunninghamiana*, but both of these species are absent from many miles of the lower portions of the rivers of north Queensland and their place is taken by *Melaleuca saligna*. This tree is known as Willow Tea-tree and Drooping Tea-tree from its graceful pendulous habit. On the Etheridge, Gilbert, Flinders and other rivers, the Willow Tea-trees reach a height of from sixty to seventy feet and hang gracefully over the stream sometimes meeting overhead and forming a canopy, while charming vistas are produced between the avenues of papery-barked stems, the water and the pendulous foliage.

Leichhardt first met with this tree on Hughs's Creek, near the Isaacs River, (*op. cit.*, p. 140), and calls it "the drooping tea-tree (*Melaleuca leucodendron* ?)." He writes: "We found it afterwards at every creek and river." On the 9th June, 1845, when on the Lynd River, he wrote:—"We gathered some blossoms of the drooping tea-tree, which were full of honey, and when soaked, imparted a very agreeable sweetness to the water," (p. 286). He formed the opinion that "this tree cannot live on water entirely salt" (p. 390).

Flying Foxes *(Pteropus poliocephalus)* camp in some of the denser vegetation near the Gulf, and at night they visit the rivers for the purpose of obtaining the honey from the Willow Tea-tree flowers.

Bentham included *M. saligna* as a variety of *M. leucadendron*, but Messrs. Baker and Smith point out that it should have specific rank.[1] In general appearance and habit the tree is quite distinct from various other Melaleucas which in the past have been placed under *M. leucadendron*.

The trees identified as *Melaleuca Cunninghamii* Schau. (No. 3922) have leaves from four to eight inches long and up to two and a quarter inches wide, with six or seven prominent parallel veins, and are from twenty to twenty-five feet high at Croydon and Normanton.

M. symphyocarpa (No. 3914) was seen where the road crosses the Gilbert River, a specimen being snatched off a tree from the passing coach.

The trees provisionally identified as *Eucalyptus gracilis* (No. 3930) are growing a few miles to the east and south of Normanton on a sandy Cretaceous formation containing ironstone pebbles. They are small box trees from ten to thirty feet high, often with branching stems suggestive of mallee, leaves bright green and shiny, yielding no smell of oil when crushed, box bark on trunk and large branches, some small branches smooth and greenish, adult leaves from three to four and a half inches long, about 1 cm. wide, juvenile leaves up to three inches long and one and a quarter inches wide, fruits about 4 mm. long and 3 mm. in diameter.[2] Leichhardt appears to have passed through this identical forest after crossing the Norman River, the native name

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[1] "On the Australian Melaleucas and their Essential Oils." This Journal, Vol. XLVII, (1913) p. 200.

[2] See "Notes on Eucalyptus (with descriptions of New Species) No. 4," by J. H. Maiden, F.L.S. This Journal, XLIX, (1915), p. 326.

of which he gives as the "Yappar." He writes:—"The hills were composed of iron-sandstone. . . . . The intervening flats bore either a box-tree with a short trunk branching off immediately above the ground," etc., (*op. cit.* p. 337).

Eucalyptus pruinosa (Silver-leaved Box) is a common tree between Croydon and Normanton, and also at Donor's Hill, Cowan Downs and Boomarra on the Normanton-Cloncurry road. When observed at a distance it is identical in appearance with *E. melanophloia* (Silver-leaved Iron-bark), but at close range the barks are seen to be totally different, that of the latter being hard, dark and deeply furrowed, while that of *E. pruinosa* is a light grey box bark (Plate LXI). The branchlets of *E. pruinosa* are usually very angular, often quadrangular, and fruits from Normanton measure as much as 9 mm. long by 8 mm. in diameter, while some from Cowan Downs are 1 cm. long by 6 mm. in diameter.

Seedlings—*Hypocotyl* erect, terete, pale green, glabrous, up to 1·3 cm. long.

Cotyledons slightly emarginate or almost reniform, entire, 5 to 8 mm. by 3 to 4 mm., upperside green, underside paler, glabrous; petioles 3 to 4 mm. long.

Seedling foliage opposite, entire, glabrous, elliptical-lanceolate, tapering into a short petiole of not more than 1 to 2 mm. long: midrib prominent on underside, lateral veins few, and arranged at angles of about 50° to 60° with midrib, reticulate between, intramarginal vein obscure on margin or absent. On a seedling six inches high the second pair of leaves measured about 1 cm. each, while those of the sixth to the tenth pair measured from 2 to 2·5 cm. with a width of 6 to 7 mm., the internodes increasing in length from about 1 to 1·8 cm. In one specimen the first internode measured 2 cm.

The seedling leaves of this species are very similar to those of *E. melanophloia*,[1] and are of interest seeing that they taper towards the base into a very short petiole, while the adult leaves are sessile and cordate.

The Boxes and Ironbarks have several characters in common, such as hard timbers, shape of anthers, and in general, a preference for basic rather than siliceous soils, and the two groups approach each other more closely in these two glaucous leaved species than in any others. There is no doubt, as Mueller points out, (Eucalyptographia) that Leichhardt records the Silver-leaved Ironbark on many occasions instead of the Silver-leaved Box. Near Normanton cemetery *E. pruinosa* is growing with *E. tetrodonta* on a soil rather more siliceous than that usually selected by box trees.

Eucalyptus melanophloia is common near Durham and Cumberland between Georgetown and the Gilbert River, but was not noticed to the westward.

The species referred to as White Box (No. 4162) was seen over a very wide area, but so far has not been identified and may be undescribed. It was first noticed near Frewhurst, between Alma-den and Forsayth, and was afterwards seen at various points including Forsayth, Georgetown, Croydon and towards Normanton. It also occurs near the Corella River about thirty miles north of Cloncurry, but is absent from the black soil plains of the lower Flinders. Its average height is about thirty to forty feet and it has a light grey box-bark on the trunk and large branches.

Juvenile leaves thick, ovate, up to four inches long by two and three-quarter inches broad, midrib prominent, lateral veins arranged at an angle of approximately 60° with

[1] "The Evolution of the Eucalypts in Relation to the Cotyledons and Seedlings," by Cuthbert Hall, M.D., Proc. Linn. Soc. N. S. Wales, Vol. xxxix, 498, (1914).

the midrib, intramarginal vein very close to the edge, petioles about 6 to 8 mm. long.

Adult leaves thick in texture, ovate-lanceolate to lanceolate, from two to four inches long, greyish-green, lateral veins at angle of about 45° to 50° with midrib, intramarginal vein practically on the edge, petioles from about 1·5 to 2·5 cm. long, the twigs sometimes glaucous.

Fruits obconical, 4 to 5 mm. long, 4 to 5 mm. in diameter, in the Georgetown and Croydon specimens, pedicels 2 to 3 mm. long, valves exserted. Some of the fruits of the Corella River specimens (No. 4163) are 6 mm. long by 7 mm. in diameter. These latter specimens would not have been obtained but for an accident which delayed the coach for half an hour.

This species has some affinities with *E. microtheca*, (Coolabah) but its fruits are more conoid than those of the latter species, the pedicels and leaves much thicker, and the venation different. Moreover the Coolabah grows on the black soil plains, a situation which this White Box seems to avoid. Neither buds nor flowers have been seen, but an effort is being made to procure them.

Eucalyptus miniata was observed at various points between Alma-den and Normanton on siliceous soils, and is usually known as Woolybutt, although that name is also given to *E. clavigera*. It is sometimes spoken of as "Tobacco Pipe Gum," from the resemblance of the large ribbed fruits to the bowl of a pipe, and is the "Melaleuca Gum" of Leichhardt. The lower portion of the trunk is covered with a remarkable yellow, scaly to papery bark, and the branches are smooth (Plate LIX).[1]

Eucalyptus rostrata (River Red Gum) was noticed near Forsayth, but was not seen afterwards on either the Etheridge River, the Gilbert or the lower Flinders.

[1] See "Critical Revision of the Genus Eucalyptus," by J. H. Maiden, F.L.S., Part XXII, p. 37.

E. setosa is growing in, and around the town of Normanton, on a mixed siliceous and ironstone formation, and was not noticed to the eastward near Croydon or Georgetown. It is a low shapely spreading tree about thirty to forty feet high, and seems closely related to the Angophoras, having the general appearance of *A. subvelutina*, while its broadly winged seeds show its affinity with the bloodwood group of Eucalypts. It is remarkable for its rusty hispid branchlets and inflorescence, and its sessile, opposite, cordate leaves. The bark of this tree is rough and somewhat scaly, and a note made when near one of the trees reads:—"bark between that of an Angophora and *Eucalyptus robusta*."

Ficus glomerata (Red Fig) was growing as large trees on the bank of the Etheridge at Georgetown. Clusters of fruits are attached to the stem or the thick part of the branches, and as they ripen they become red and are then about one inch in diameter and emit a most agreeable perfume. Although these fruits are considered edible, their fragrance is superior to their taste.

The plant provisionally identified as *Pandanus aquaticus* was noticed at intervals right from Cairns to Normanton on the Gulf of Carpentaria. It ranges from about fifteen to twenty feet high, the head being divided into several branches with leaves at least four or five feet long. The suspended fruits are collected in an ovate to globular head of about six inches diameter. On the young plants the leaves grow spirally up the stem, but the trunks of the adult trees are bare although the spiral scars from the fallen leaves remain visible for a long time. From this feature this palm-like plant is sometimes called a Screw Pine. The particular plants noticed showed nothing of any adventitious descending roots, and were always found close to streams or on moist flats. In going southerly from Normanton to Cloncurry the Pandanus was not seen.

NORMANTON TO CLONCURRY.

The distance from Normanton to Cloncurry is about 260 miles south by west, and the journey, which was made by coach, occupied five days, practically the whole of the travelling being done in daylight. For the first fifteen miles or so the country is a somewhat sandy Cretaceous formation, but for the next hundred miles the rich soil of the lower Flinders is followed, a great portion consisting of black soil plains. A few low sandstone ridges are crossed, some curiously weathered limestone is seen at Granada, and towards Cloncurry some slate formation occurs. Generally speaking the country is level, the ascent for the whole distance being 600 feet, Cloncurry being 633 feet above sea level. The rainfall around Normanton is upwards of thirty inches per annum, and about twenty inches at Cloncurry, the bulk of which falls between December and April.

It was noticed at about eight or ten miles from Normanton that most of the Eucalypts were leaning to the westward, the inference being that some of the strongest winds blow in that direction while the ground is soft. Another feature connected with the winds around Normanton is that in some of the winter months, including August, the wind off the land is so strong as to hold back the water of the Gulf, which takes with it that of the lower portion of the Norman River, until it becomes too shallow for the regular trading steamers to come into the river.

From observations made of the great quantities of sand in the beds of several rivers, which comes from granitic areas towards their sources and from Cretaceous sandstone hills lower down, it is evident that in the wet season enormous quantities of this sand must be carried into the Gulf and gradually lessen the depth of water around the coast.

The following is the list of plants noticed near the road between Normanton and Cloncurry:—

CAPPARIDACEÆ: *Capparis lasiantha* R. Br., (No. 3938, a beautiful flowering woody climber, sometimes called Native Honeysuckle), *C. Mitchelli* Lindl., (Native Orange or Pomegranate).

BIXIACEÆ: *Cochlospermum Gillivræi* (Native Cotton, near Cowan Downs).

STERCULIACEÆ: *Melhania incana* Heyne? (at Quamby).

TILIACEÆ: *Grewia polygama* (Jelly Boys).

MELIACEÆ: *Owenia acidula* F.v.M., (Emu Apple, the Gruie of the Bourke country, seen at intervals the whole way, some particularly shapely trees occurring at Granada).

RHAMNACEÆ: *Ventilago viminalis* Hook., (Vine Tree or Supple Jack).

SAPINDACEÆ: *Atalaya hemiglauca* (Whitewood, seen at intervals most of the way), *Heterodendron oleæfolium* Desf.? (Western Rosewood).

LEGUMINOSÆ: *Tephrosia remotiflora* F.v.M., (at Quamby), *Bauhinia Carronii* (seen at intervals all the way), *Acacia sentis* F.v.M., *A. Cambagei* R. T. Baker (Gidgea), *A. stenophylla* A. Cunn., *A. hemignosta*, *A. Chisholmi* Bailey, *A. umbellata* A. Cunn., (No. 4164), *A. julifera?* (near Normanton), *A. torulosa?* (No. 4165, at Granada), *A. plectocarpa*, (No. 3935, 8 to 10 feet high, near Normanton), *A. Farnesiana* Willd., (Needle Bush or Prickly Mimosa), *A. Sutherlandi*, (No. 3937, Corktree or Weeping Mimosa).

CMBRETACEÆ: *Terminalia platyphylla* (Pear Tree).

MYRTACEÆ: *Melaleuca saligna* (Drooping or Willow Tea-tree, very large trees on banks of Flinders River, seen also on Dugald River near Granada, and it is possibly also on the Cloncurry River, which however was crossed in the dark), *M. Cunninghamii?* (on gravelly ridge between Paddy's Lagoon and Donor's Hill), *Eucalyptus gracilis* (not seen after about

seven miles from Normanton), *E. pruinosa* (Silver-leaved Box), *E. sp.* (No. 4163, a White Box near Corella River), *E. microtheca* F.v.M., (Coolabah), *E. pallidifolia* F.v.M. (Mountain Gum or White Brittle Gum), *E. rostrata* (River Red Gum), *E. clavigera* (Apple-gum, seen at about fifteen miles from Normanton and near Hazel Creek between Cowan Downs and Boomarra), *E. papuana* (No. 3938, *E. tesselaris* var. *Dallachiana*, Cabbage Gum), *E. setosa* (seen in Normanton, also at about fourteen miles out, and again between Paddy's Lagoon and Donor's Hill on gravelly ridge), *E. terminalis ?* (Bloodwood, at intervals most of the way), *E. dichromophloia ?* (Red Bloodwood, noticed close to Normanton, also between Paddy's Lagoon and Donor's Hill on gravelly Cretaceous ridge), *E. tetrodonta* (Messmate or Stringybark, not seen after about fifteen miles from Normanton), *Careya australis.*

CUCURBITACEÆ: *Cucumis trigonus* Roxb. ? (Wild Melon. According to Mr. E. Palmer a form referred to as *C. pubescens* is called "Boomarrah" by the natives on the Cloncurry).

LORANTHACEÆ: *Loranthus longiflorus*, *L. quandang* Lindl., (Mistletoe, near Boomarra).

RUBIACEÆ: *Gardenia edulis* (Bread-fruit tree).

EBENACEÆ: *Maba humilis* R. Br., (Ebony, Donor's Hill to Boomarra, with yellow ovoid fruits about 1 to 1·2 cm. long).

APOCYNACEÆ: *Carissa ovata* R. Br., (a spreading shrub known as Boorum Bush and Kunkerberry, black, oval, edible fruit, noticed from Donor's Hill to Boomarra and Cloncurry).

MYOPORACEÆ: *Eremophila Mitchelli* Benth., (Budtha or Budda of western New South Wales, noticed from Donor's Hill to Cloncurry), *E. bignoniæflora* F.v.M. (Donor's Hill), *E. longifolia* F.v.M.?

VERBENACEÆ: *Vitex trifolia* Linn., (specimen obtained at Quamby thirty miles north of Cloncurry, an Asiatic plant).

AMARANTACEÆ: *Ptilotus spicatus* F.v.M., (at Boomarra).

PROTEACEÆ: *Grevillea striata* (Beefwood of north-western New South Wales, seen at intervals from the lower Flinders), *G. sp.*, *Hakea arborescens*, *H. Cunninghamii* R. Br., (with terete drooping leaves one foot long, at Granada).

SANTALACEÆ: *Santalum lanceolatum* R. Br.

EUPHORBIACEÆ: *Excœcaria parvifolia* F.v.M., (Gutta-percha or Rubber tree, growing on the lowland).

URTICACEÆ: *Crinum flaccidum* Herb.? (known as the Plains Lily at Boomarra, comes up and flowers after the commencement of the wet season in December).

GRAMINEÆ: *Astrebla pectinata* F.v.M., (Mitchell Grass of the Flinders River plains), and var. *curvifolia* Bail., (Curly Mitchell, both excellent pasture grasses), *Anthistiria membranacea* Lindl.? (Red Grass), *Triodia irritans* (Spinifex).

Capparis lasiantha is a very different looking plant from *C. Mitchelli*. The latter grows into a large shrub or small tree, and is known as Wild Orange, while the former is a climber with hooked stipular prickles which aid it in holding on to trees over which it scrambles. From this habit it is sometimes called Lawyer Vine, though it is quite distinct from the Lawyer Vines of the coast brushes. It is spoken of as Native Honeysuckle from the slight resemblance of its flowers and its climbing habit.

Ventilago viminalis was seen intermittently the whole way from Normanton, and is known to extend southwards to Cobar in New South Wales. Although it only grows into a small tree of about twenty feet, the stems and branches of which often entwine, it has an exceedingly hard wood. In cutting into one of these trees having a diameter of about nine inches, the blade of a sharp axe may easily be broken beyond repair, portions of the broken blade remaining in the wood. An example of this once came under my personal observation.

Although the genus is widely spread over the tropics, this endemic species is the only Australian one and has a very extended range.

Acacia sentis was first noticed around Boomarra, one hundred miles north of Cloncurry, and was seen afterwards at various points towards Cloncurry and near Hughenden, growing as little trees ten to twelve feet high, and sometimes having stipular prickles. Its flowers are pale yellow and its somewhat linear phyllodes a light green. Towards the end of August 1913 the species was in full flower.

Acacia Cambagei (Gidgea or Gidgee) was first met with at about eighty miles south of Normanton, which is the most northern locality recorded for this species. It comes as far south at least as the Wilcannia district in New South Wales, and often grows on low gravelly ridges and foothills, and although it sometimes extends on to the basic black soil, it prefers a slightly more siliceous formation than that selected by its sister trees *A. pendula* A. Cunn., (Myall), and *A. homalophylla* A. Cunn., (Yarran). Around Donor's Hill, one hundred miles south of Normanton, the Gidgea is common on the Cretaceous gravelly, ironstone and somewhat sandy hills. Various writers have recorded this species from Queensland under the name of *A. homalophylla*, a very distinct tree.

Gidgea is remarkable for the very unpleasant smell of its leaves (phyllodes) in damp weather, but these are not without their virtue, for in north-western Queensland they are eagerly sought after and browsed upon by camels, and where that animal is concerned Gidgea trees are regarded as amongst the best fodder plants. The timber is freely used for fence posts, and at Cowan Downs it was being made use of for sleepers and ground plates of a new building. This species had ceased flowering on the Flinders by the end of August 1913, and young pods, often slightly falcate,

had just formed, so that the flowering period for Gidgea in this locality is towards the end of July.

Acacia stenophylla, the Eumung of western New South Wales, or River Cooba of the Lachlan, occurs to within eighty miles south of Normanton, and grows along the banks of streams, the long narrow pendulous phyllodes, sometimes bluish in colour, often hanging over the watercourse. It was noticed at various points including Richmond Downs and Winton to Longreach where it is called Native Willow. This species prefers basic to siliceous soils and is not common along creeks in sandy areas.

Acacia Chisholmi (No. 4111) was first noticed between Boomarra and Donaldson, and afterwards at various points towards Cloncurry, being known locally as Turpentine Bush. It was found at Quamby growing as shrubs six to eight feet high with rough crinkled bark like that of *A. rigens* A. Cunn. The species flowers in July, and the young pods obtained at the end of August were falcate, flat, exceedingly viscid, up to three and a half inches long, and three to four lines broad. Many of the flowers had been infested with a large, woolly-looking gall, formed by the larvæ of a gall gnat, identified by Mr. W. W. Froggatt as *Cecidomyia sp.*

Acacia umbellata is growing on a Cretaceous, gravelly, ironstone ridge about fifteen miles north of Donor's Hill, where it is an open spreading shrub of about eight to ten feet high. The only pod obtained is somwhat terete and measures one and a half inches.

The plant identified as *Acacia torulosa* (No. 4165) grows close to the Dugald River at Granada, fifty miles north of Cloncurry, and is about ten feet high. Young pods were just forming at the end of August, and these were narrow and viscid.

Acacia Farnesiana (Needle Bush or Prickly Mimosa) was seen as spreading shrubs practically the whole way from Normanton to Cloncurry, and is a common Queensland species as well as being indigenous in other tropical countries. Its seeds will germinate after having been immersed in sea water for six months. (This Journal 1915, p. 94).

Acacia Sutherlandi is remarkable for its long pendulous branches (Plate LX), and is known as Cork Tree and Weeping Mimosa. It grows in clumps on the plains near the lower Flinders, and is from thirty to fifty feet high, the trunk being usually covered with a rough corky bark, very similar to that of *A. Bidwilli*, an erect tree.

The trees identified as *Eucalyptus microtheca* (Coolabah, No. 4002) extend for very many miles along the lower Flinders, often growing on low flat land subject to inundation by floods. The trees range from thirty to forty feet high with a very dark grey box bark on the trunk, and a lighter grey on the branches, so that in general appearance they are exactly similar to trees of *E. bicolor* A. Cunn., (*E. largiflorens* F.v.M.). The fruits obtained are arranged in panicles on slender peduncles and are almost hemispherical, 3 mm. long, and 3 mm. across, the valves not protruding beyond the rim except in a very few cases and then only to the extent of about ·3 mm. The wood examined is very deep brownish-red to almost black.

These trees differ in two particulars from those recognised as *E. microtheca* on the Darling River around Bourke, in that the latter have smooth, perfectly white branches, and valves exserted in a most pronounced manner. Both favour basic rather than siliceous soils. The wood of the Bourke trees is brownish-red, of a lighter shade than that of the Gulf Coolabah, but it is considered by some who live near the Flinders that those trees which are inundated during the wet season have darker timber than those above the

flood-line. At the head of the Flinders, near Hughenden, Coolabah trees were seen with box bark on the trunk and lower portion of the large branches, the remainder being smooth, and having fruits with exserted valves. Similar trees were noticed between Hughenden and Winton, and are common around Longreach, and eastwards intermittently to Rockhampton, some of the young trees at Longreach having the upper portion of the trunk white, as well as the branches. Briefly then, it would seem that the Bourke form of *E. microtheca* with the upper portion of the tree smooth, and having fruits with exserted valves, extends northerly to the upper Flinders with some variation in the extent of box bark on the trunk, while near the Gulf of Carpentaria the whole tree is covered with box bark and the fruits have scarcely exserted valves. These differences, although meriting further investigation as being possible adaptations to environment, cannot in themselves be considered specific.[1]

Eucalyptus pallidifolia is an interesting species which was seen at various points on the slightly elevated Cretaceous sandy or gravelly areas, avoiding all basic formations. It was first met with about fifteen miles north of Donor's Hill, and was last seen near Cloncurry on what appears to be Silurian slate. Its local names are Mountain Gum, or White Brittle Gum, and in general appearance it resembles a spreading stunted form of *E. maculosa* R. T. Baker, its average height being about thirty feet. (Plate LVIII, fig. 1). The type came from North Western Australia, and Mr. Ross McLean of Bowen informed me that this species was very common towards the western border of North Queensland, but was rare east of the Flinders. The timber is hard, short grained, and red, the sapwood

[1] See "A Critical Revision of the Genus Eucalyptus," by J. H. Maiden, Part XI.

pale yellow, and the white bark thin, measuring about 5 mm. in thickness. In August 1913, some Mountain Gums were pointed out by the coach driver which had suffered from a severe hailstorm about four years before. The effect on the thin bark was that the southern sides of the trees had been studded with hail marks as though hit with bullets, and after four years were still covered with brown scars.

A seedling of this species, about one foot high, has developed a pair of nodules in the axils of the cotyledons.

Eucalyptus rostrata (River Red Gum) was not noticed on the lower Flinders, but was met with near Cowan Downs at about one hundred and twenty miles from Normanton, and at various points to the southward.

Hakea Cunninghamii and *H. lorea* have a remarkable appearance from the drooping habit of their long grey needle-shaped leaves, those of the former being one foot and those of the latter up to two feet long. In appearance the trees are suggestive of a species of Casuarina, and on catching sight of small ones for the first time, an observer is likely to see a fancied resemblance between one of these melancholy looking plants, and an old grey haired lady standing in an attitude of dejection, with her hair streaming all round.

The curious leaves of these species and others of the genus are fine examples of some of the xerophytic characters developed by Australian plants. *H. Cunninghamii* belongs chiefly to the Northern Territory, and does not appear to have been previously recorded for Queensland.

A species of palm tree, said to be Cabbage Palm, possibly a Livistona, grows near Quamby, but I was unable to see it.

CLONCURRY TO HUGHENDEN.

The journey from Cloncurry to Hughenden was made by train, the latter portion, after passing Richmond, being

travelled in the dark. For the first twenty miles or so the country is hilly, the formation apparently being Silurian slate, but the remainder is for the most part made up of great undulating open downs, including the famous Richmond Downs with their rich pasture in good seasons. These downs, which are really great plains in many portions, have a rich flora which is evident in the rainy season, but in August the grasses are usually dry and little can be identified from the train except trees and shrubs.

The following plants were noticed:—*Owenia acidula* (Emu Apple), *Ventilago viminalis* (Vine Tree or Supple Jack), *Atalaya hemiglauca* (Whitewood), *Bauhinia sp.*, *Acacia sentis* (in flower), *A. Cambagei* (Gidgea), *A. stenophylla* (on creek banks between Julia Creek and Nelia), *A. Chisholmi?* (Turpentine Bush), *A. Farnesiana* (Needle Bush or Prickly Mimosa), *A. sp.*, (like *A. Sutherlandi*), *Eucalyptus sp.*, (a White Box, probably the same as No. 4163, seen only near Cloncurry), *E. terminalis?* (Bloodwood, at Cloncurry, and in flower between Kaampa and Oorindi), *E. pallidifolia* (Mountain White Gum, near Cloncurry), *E. papuana* (Cabbage Gum with boles white to the ground), *Grevillea striata*, *Hakea arborescens* (near Cloncurry), *H. sp.*, (probably either *H. Cunninghamii* or *H. lorea*).

HUGHENDEN TO PRAIRIE.

Prairie is situated nearly thirty miles easterly from Hughenden on a tableland of chiefly sandstone formation, though only some portions of it appear to be sandy. The plants identified were:—

PITTOSPORACEÆ: *Bursaria spinosa* Cav.

MALVACEÆ: *Fugosia australis* Benth., (at Baronta).

RHAMNACEÆ: *Ventilago viminalis* (Vine Tree).

SAPINDACEÆ: *Atalaya hemiglauca* (Whitewood), *Heterodendron oleæfolium* (Western Rosewood).

LEGUMINOSÆ: *Cassia pleurocarpa* F.v.M., *Bauhinia sp.*, *Acacia sentis*, *A. Cambagei* (Gidgea), *A. Chisholmi?* (Turpentine Bush), *A. gonoclada* F.v.M. (No. 3966), *A. pityoides* F.v.M. (No. 3962), *A. cibaria* F.v.M. (No. 3961), *A. leptocarpa* A. Cunn.? (No. 3963), *A. Farnesiana*, *A. Sutherlandi?* (between Jardine Valley and Baronta).

MYRTACEÆ: *Melaleuca leucadendron?* var. *viridiflora* (ten feet high, papery bark, flowers yellowish-green, on sandy soil, between Baronta and Prairie), *Eucalyptus crebra* (Narrow-leaved Ironbark, with large fruits up to 7 mm. long by 6 mm. in diameter), *E. microtheca* (Coolabah, with the branches generally smooth), *E. rostrata* (River Red Gum, near Jardine Valley), *E. papuana* (Cabbage Gum, at Prairie), *E. setosa*, *E. terminalis?* (Bloodwood, at Prairie), *E. dichromophloia?* (Red Bloodwood, at Prairie).

LORANTHACEÆ: *Loranthus longiflorus* (with *Eucalyptus microtheca* as host, at Prairie).

COMPOSITÆ: *Helichrysum apiculatum* DC.?

APOCYNACEÆ: *Carissa lanceolatus* R. Br., (Boorum Bush, at Prairie).

MYOPORACEÆ: *Eremophila Mitchelli*, *E. longifolia*.

PROTEACEÆ: *Grevillea striata*, *Hakea lorea*. ?

SANTALACEÆ: *Santalum lanceolatum*.

The plants identified as *Acacia gonoclada* (No. 3966) were found on sandy soil near Baronta, at an elevation of about 1400 feet, and reach a height of about ten feet. The cylindrical flower spikes are from three-quarters of an inch to one inch long with peduncles of about 4 mm. The young phyllodes and young pods are very viscid, the latter being flat, up to 5 cm. long by 5 mm. broad. The phyllodes measure from four to five and a half inches long, and from three-quarters of an inch to one and a half inches broad, with several prominent nerves confluent with the lower margin near the base. These dimensions are slightly in excess of those quoted by Bentham for flowers, pods and phyllodes.

Acacia pityoides (No. 3962) is growing near *A. gonoclada*, reaching a height of ten feet, with a fairly smooth bark, and branching into six or eight stems. The linear-subulate phyllodes are from four to five inches long, rarely six inches, and the narrow pods average about two and a half inches long.

Acacia cibaria (No. 3961, Wirewood) was also growing on the sandy tableland, some of the trees being fifteen feet high, with narrow linear phyllodes from six to thirteen inches long, and twisted pods (contracted between the seeds), from four to seven and a half inches long. The bark is scaly and somewhat furrowed, the wood, which is used for posts, is pale yellow near the outside and dark brown towards the centre.

Eucalyptus setosa is growing on sandy soil between Baronta and Prairie, the trees being about twenty feet high, with a stem diameter of ten inches and the wood dark brown.

HUGHENDEN TO WINTON.

In going from Hughenden to Winton, the divide between the Gulf of Carpentaria and the Lake Eyre waters is crossed at Whitewood, where the elevation is 1,028 feet, Winton being situated on a tributary of the Diamantina River, and is 614 feet above sea level. For the whole distance the country is made up of undulating open plains or downs dotted with a few trees here and there.

The following is a list of plants seen from the train:—*Capparis lasiantha, Owenia acidula, Ventilago viminalis, Atalaya hemiglauca, Bauhinia sp., Acacia Cambagei, A. stenophylla, A. Farnesiana, Eucalyptus microtheca, Helichrysum sp.?, Eremophila Mitchelli.*

WINTON TO LONGREACH.

This portion of the journey was made by motor car, the distance being one hundred and twenty-five miles. For

the first half the country is level, open, treeless plains, though several flat topped hills, possibly outliers of Upper Cretaceous formation, may be seen on the right. Not a single tree was recorded up to sixty-five miles, but beyond this point the following plants were noticed:—*Capparis lasiantha*, *Flindersia maculosa* (Leopardwood, Meliaceæ), *Ventilago viminalis*, *Atalaya hemiglauca*, *Heterodendron oleæfolium*, *Cassia sp.*, *Acacia homalophylla* A. Cunn.? (Boree), *A. Cambagei* (Gidgea), *A. stenophylla* (Native Willow), *A. Bidwilli ?*, *A. Farnesiana*, *Eucalyptus microtheca* (Coolabah), *E. terminalis ?* (Bloodwood), *E. rostrata* (River Red Gum, towards Thomson River), *Loranthus sp.*, *Carissa ovata*, *Eremophila Mitchelli*, *Grevillea striata*, *Santalum lanceolatum*.

At a little more than half way from Winton to Longreach the trees provisionally identified as *Acacia homalophylla* (Boree, No. 3971) are first met with, and are common around Longreach, reaching a height of about twenty feet. The linear, silvery phyllodes, finely striate with numerous parallel obscure veins, are about three to four inches long, by 2 to 4 mm. broad, and usually with slightly curved points. The species evidently flowers late in July, for on 4th September young glaucous, flat, narrow pods were obtained, measuring from two to three inches long by 3 to 4 mm. broad. In general appearance these trees closely resemble the Gidgea (*A. Cambagei*), but the phyllodes and pods of the latter are broader and the veins more prominent, besides other differences.

LONGREACH TO ROCKHAMPTON.

Longreach is 612 feet above sea level, and 428 miles by rail from Rockhampton, and is situated on the Thomson River, which, after being joined by the Barcoo, is known as Cooper's Creek and flows into Lake Eyre. The surrounding

country consists of level to undulating plains, sparsely timbered, but after Barcaldine is passed the conditions change, and fairly well-timbered forest land may be seen on both sides of the railway line, practically all the way to Rockhampton. On a sandy area extending from near Geera to about Pine Hill there is a most interesting and varied flora, and owing to its sandy nature a considerable portion of this area is known as The Desert. The annual rainfall over a great portion of this tract of country, from Barcaldine to the Dawson River, ranges from about twenty to thirty inches, increasing to the eastward, and with less than twenty inches at Longreach. The Main Divide is crossed on a sandy plateau near Jericho at an altitude of scarcely 1,200 feet above sea level, and about fifty miles to the eastward, the Drummond Range near Pine Hill reaches an elevation of about 1,500 feet. This comparatively low gap in the Main Divide allows the drier western conditions to come on to the eastern watershed, with the result that many of the interior plants have invaded the coastal area, and some occur as far east at Rockhampton. On the other hand, the presence of this drier western climate prevents the growth of such large areas of brush or jungle, as may be seen in other places on the eastern slope, where the divide is higher and the moisture greater. The first sign of a little brush is seen from the train between the forty-ninth and fiftieth mile-posts from Rockhampton, but at no point near the line does the Malayan element in the flora predominate as on many other portions of the east coast.[1]

Practically the only collecting done on this route was at Bogantungan, two hundred miles east of Longreach, and some specimens were sent from Geera by Mr. H. C. Cullen, so that considering the distance travelled, the appended

[1] For a general description of the vegetation over the eastern portion of this area, see a paper by P. A. O'Shanesy, F.L.S., "Contributions to the Flora of Queensland," (1880).

list of plants chiefly seen from the train is meagre, though sufficient to give an idea of the general character of the flora. Two or three beautiful flowering Acacias were seen in the desert but could not be identified from the train.

The following plants were noticed between Longreach and Rockhampton:—

CAPPARIDACEÆ: *Capparis lasiantha*, *C. Mitchelli* (Pomegranate), *Apophyllum anomalum* F.v.M.? (near Dartmouth).

PITTOSPORACEÆ: *Pittosporum phillyrœoides* DC., (near Geera), *Bursaria spinosa*.

STERCULIACEÆ: *Sterculia diversifolia* G. Don (Kurrajong, near Alice River and Bogantungan), *S. rupestris* Benth., (Bottle Tree, common from Emerald towards Rockhampton, sometimes with a diameter of five to six feet).

TILIACEÆ: *Grewia polygama* (at Bogantungan).

RUTACEÆ: *Geijera parviflora* Lindl. (Wilga, a beautiful shade tree, near Geera and Emerald).

MELIACEÆ: *Owenia acidula* (at various points, trees up to 30 feet high between the 82 and 83 mile-posts from Rockhampton).

CELASTRINEÆ: *Celastrus Cunninghamii* F.v.M.

RHAMNACEÆ: *Ventilago viminalis* (Vine Tree), *Zizyphus jujuba* (Jujubes, near Rockhampton), *Alphitonia excelsa* (near Jericho, Yamala and Stanley, a widely distributed species).[1]

SAPINDACEÆ: *Cupania anacardioides* A. Rich., (trees 20 feet high at Bogantungan), *Atalaya hemiglauca* (Whitewood), *Heterodendron oleæfolium*, *Dodonæa attenuata* A. Cunn. (Hopbush).

LEGUMINOSÆ: *Lotus australis* Andr., (at Bogantungan. This endemic species belongs to a genus widely spread over the tropical and temperate regions of the world), *Cæsalpinia Gillesii* Wall. (near Geera), *Cassia sp.*, *Bauhinia sp.*, *Acacia*

[1] Notes on the Native Flora of New South Wales by R. H. Cambage, Part IX, Proc. Linn. Soc. N. S. Wales, Vol. XXXVII, p. 649, (1912).

salicina Lindl. var. *varians* (large spreading trees, the Cooba of the Lachlan River, seen at various places), *A. decora* Reichb., (at Bogantungan), *A. homalophylla ?* (Boree, from Longreach to Geera), *A. Cambagei* (Gidgea, Longreach to Jericho), *A. stenophylla* (near Geera), *A. harpophylla* F.v.M., (Brigalow, first met with between Alice and Jericho, afterwards seen at intervals to Rockhampton; near the Comet River there are miles of Brigalow scrub), *A. excelsa* Benth., (Ironwood, in The Desert), *A. complanata* A. Cunn.? (near the fifty mile-post), *A. cibaria* (Wirewood, common in The Desert), *A. doratoxylon* (Lancewood, at various points), *A. torulosa ?* (near Geera), *A. Cunninghamii* Hook.? (Nos. 3984 and 3985, at Bogantungan), *A. aulacocarpa* (near Rockhampton), *A. holosericea* (near Rockhampton), *A. polybotrya* Benth. var. *foliolosa* (20 to 25 feet high, with bipinnate leaves, at Bogantungan, No. 3982), *A. Farnesiana.*

MYRTACEÆ: *Calythrix longiflora* F.v.M. (near Geera), *Callistemon viminalis* (with red flowers, on creek bank between 38 and 39 mile-posts from Rockhampton), *Melaleuca saligna ?* (Willow Teatree, on Dawson River, and probably again between 31 and 33 mile-posts, seen only from train), *M. genistifolia ?*, *M. leucadendron* var. *viridiflora* (near Walton), *Eucalyptus Thozetiana* F.v.M.? (between Weemah and Yamala), *E. populifolia* Hook., (Poplar Box, or Bimble Box), *E. hemiphloia* F.v.M., (Box, from Wallaroo to Rockhampton, the common Box around Parramatta), *E. Cambageana* Maiden (this Journal, 1913, p. 91, Blackbutt), *E. melanophloia* (Silver-leaved Ironbark, at various places from about the Alice River eastwards) *E. sp.*, (a distinct looking species of Ironbark, somewhat resembling *E. melanophloia*, leaves rather lanceolate, fairly common between Geera and Lochnagar), *E. crebra* (Narrow-leaved Ironbark, at Bogantungan and to the eastward, doubtfully identified from the train between Jericho and Beta), *E. Raveretiana* F.v.M., (near Rockhampton), *E. microtheca* (Coolabah, at intervals from Longreach into the

suburbs of Rockhampton), *E. rostrata* (River Red Gum, on many streams to Emerald, and doubtfully identified from the train on the Dawson), *E. exserta* F.v.M., (from Wallaroo to Rockhampton), *E. tereticornis* (Forest Red Gum, from Bogantungan to Rockhampton), *E. alba* (Poplar Gum, near Rockhampton), *E. tesselaris* (Moreton Bay Ash, at Bogantungan and to the eastward), *E. papuana* (Cabbage Gum, at intervals from Barcaldine all the way, generally white to the ground), *E. setosa ?* (doubtfully identified from the train between Geera and Lochnagar), *E. peltata ?* or *E. Leichhardtii* Bailey? (Yellow Jack, with rough scaly bark to branchlets, seen only from the train between Alice and Jericho, and again between Jericho and Beta), *E. terminalis ?* (Bloodwood, from Barcaldine at intervals the whole way), *E. dichromophloia ?* (Red Bloodwood, at Bogantungan and near Rockhampton), *E. maculata* Hook. var. *citriodora*, (Citron-scented or Lemon-scented Gum, near Coowarra and Wallaroo), *E. trachyphloia* F.v.M.? (small trees of the Bloodwood group, growing in spreading clumps between Lochnagar and Alice, identification doubtful), *Tristania suaveolens* Sm., (only seen near Rockhampton), *Careya australis* (near Rockhampton).

CACTACEÆ: *Opuntia sp.* (Prickly Pear. Naturalised and in places extending for miles in the Emerald to Comet River and Blackwater districts).

LORANTHACEÆ: *Loranthus sp.*, (with *Eucalyptus melanophloia* as host, near Jericho), *L. sp.* (near Emerald).

COMPOSITÆ: *Minuria integerrima* Benth., (near Geera), *Olearia subspicata* Benth., (near Geera), *Helichrysum bracteatum* Willd., (at Bogantungan).

GOODENIACEÆ: *Goodenia ovata* Sm., (at Bogantungan).

CAMPANULACEÆ: *Wahlenbergia gracilis* (Blue Bell).

APOCYNACEÆ: *Carissa ovata* (Boorum Bush or Kunkerberry of Cloncurry), *Alstonia constricta* F.v.M. ? (at Bogantungan).

MYOPORACEÆ: *Myoporum sp.* (near Geera), *Eremophila Mitchelli* (at various points), *E. longifolia* (near Longreach and Bogantungan), *E. maculata* F.v.M., (near Geera).

LABIATÆ: *Ajuga australis* R. Br. (at Bogantungan).

AMARANTACEÆ: *Gomphrena canescens* R. Br.? (near Geera).

PHYTOLACCACEÆ: *Codonocarpus australis* A. Cun.,(Bell-fruit, near Geera, Bogantungan and Herbert's Creek).

PROTEACEÆ: *Grevillea chrysodendron* (near Geera), *G. striata* (at Bogantungan and Dingo), *G. sp.* (near Jericho, with white flowers), *Hakea lorea* (Bogantungan), *H. leucoptera* R. Br., (near Geera; the Needlewood of western New South Wales).

THYMELACEÆ: *Pimelea sericostachya* F.v.M., (at Bogantungan).

SANTALACEÆ: *Exocarpus cupressiformis* Labill., (Native Cherry, at Bogantungan).

EUPHORBIACEÆ: *Petalostigma quadriloculare* (Quinine or Bitter Crab, at various points between Bogantungan and Duaringa), *Macaranga Tanaria* J. Muell., (at Rockhampton).

CASUARINACEÆ: *Casuarina Cambagei* (Belah, around Weemah and at intervals to Woodend near Rockhampton), *C. Luehmanni* (Bull Oak, from Yamala to Coowarra), *C. Cunninghamiana* (River Oak, from Bogantungan to near Rockhampton).

CONIFERÆ: *Callitris robusta* R. Br.,(Cypress Pine, seen at various points).

ORCHIDACEÆ: *Cymbidium sp.*, (most of the way).

LILIACEÆ: *Xerotes longifolia* R. Br., (at Bogantungan), *X. leucocephala* R. Br., (near Geera).

GRAMINEÆ: *Themeda Forskalii* Hack., (*Anthistiria ciliata* L., Kangaroo grass).

FILICES: *Adiantum æthiopicum* L., (Maiden Hair Fern), *Cheilanthes tenuifolia* Sw., (both at Bogantungan).

The trees provisionally identified as *Eucalyptus Thozetiana* were seen only between Weemah and Yamala, and the original note concerning them made in the passing train reads:—"An erect gum tree of fair size with narrow leaves slightly shining; white to ground; a fresh species." Their height averaged about fifty feet and they probably form the identical group referred to by Tenison-Woods in 1882 as *E. gracilis*, (*Op. cit.*, Vol. VII, p. 338), and also by P. A. O'Shanesy (*Op. cit.*, p. 24).

Eucalyptus Cambageana, the Blackbutt of the Comet River and Coowarra districts was first noticed between Jericho and Beta, thence onwards at intervals to Gogango, often growing with *Acacia harpophylla* (Brigalow).

Eucalyptus exserta was first noticed between Wallaroo and Duaringa. It is an umbrageous pendulous tree from forty to seventy feet high, with slightly fibrous, brown bark somewhat resembling that of the Peppermint group, and has fruits like those of *E. tereticornis*, but with remarkably exserted valves.

Trees of *Eucalyptus Raveretiana* were seen on the creek bank between the seventeenth mile-post and Stanwell, and were noted as resembling a round-leaved Coolabah (*E. microtheca*).

Eucalyptus populifolia, the Poplar Box or Shiny-leaved, or Bimble Box of western New South Wales, was not seen on the Flinders or Diamantina waters nor at Longreach. It was first met with between Salturn and Barcaldine to the east of Longreach, while between Barcaldine and Geera it is very common. How far northward of Geera it extends I unable to say, but, there are miles of it between Alice and Jericho, and it goes eastward to Rockhampton, and comes southerly to Wyalong and Wentworth in New South Wales. Although it is one of the well-known western species, it cannot be said to be common on the black-soil

plains, but prefers a lighter soil. This may account for its absence from Richmond Downs and around Winton. In New South Wales the eastern margin of the habitat of this species roughly coincides with the western margin of *E. albens* Miq., (the White Box of the western slopes), but in places the boundaries overlap.

The Cymbidium, which was noticed growing in the hollow portions of trees at various points most of the way, was probably *C. canaliculatum* R.Br., which species is found in a somewhat similar though slightly cooler climate around Boggabri in this State.

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During the whole of the hurried journey described in this paper, and which covered some of the drier rather than the moist portions of Queensland, only about thirty-one species of Eucalyptus and forty species of Acacia were noticed, numbers which would be greatly exceeded for both these genera in a very much shorter distance in any portion of the eastern coast of Australia. It is of interest to note, as contrasting the flora of this tropical climate with that of the cooler southern latitudes, that not a single species of Eucalyptus or Acacia mentioned in this list is recorded for Tasmania.

In travelling over the western portions of tropical Queensland, and noting its general flora in which are many adaptive xerophytic characters, one cannot help being impressed with the hardiness of the vegetation in such a hot climate with, in places, only a moderate rainfall. The question naturally arises, how do the seedlings manage to survive? The explanation appears to lie in the fact that the seeds germinate in the wet season during the early part of the year, and the seedlings grow rapidly during the moist period, so that by the end of the dry though temperate winter, many of them are sufficiently strong to survive

until the return of rainy weather in December or January, and thus become established.

The reason that many native plants have restricted habitats is not only owing to their preference for certain soils or to differences of rainfall in various localities, but because it is often difficult for the seedlings to establish themselves under fresh conditions, and many plants will thrive in localities away from their natural home if safe-guarded during their infancy.

I wish to express my thanks to Mr. J. H. Maiden, F.L.S., and Mr. E. Cheel, for assistance and corroboration in the identification of a number of plants, to Miss K. Hillcoat of Boomarra, Cloncurry, and Mr. H. C. Cullen formerly of Geera, for supplementing my collection of specimens.

Explanation of Plates.

Plate LVII, Fig 1.—*Eucalyptus clavigera* A. Cunn., Apple-Gum, showing tessellated bark at base. Alma-den, North Queensland.

Fig. 2.—*Eucalyptus papuana* F.v.M., Cabbage Gum. Alma-den. The bark of this species is often white to the ground and seldom rougher than that shown in photograph.

Plate LVIII, Fig. 1.—*Eucalyptus pallidifolia* F·v.M., Mountain Gum or White Brittle Gum. Cowan Downs, Normanton-Cloncurry Road.

Fig. 2.—*Terminalia platyphylla* F.v.M., Pear Tree, Georgetown.

Plate LIX.—*Eucalyptus miniata* A. Cunn., Woollybutt or Tobacco-pipe Gum. Croydon, North Queensland.

Plate LX.—*Acacia Sutherlandi* F.v.M., Cork-tree or Weeping Mimosa. Donor's Hill, Flinders River.

Plate LXI.—*Eucalyptus pruinosa* Schauer, Silver-leaved Box, Boomarra, Normanton to Cloncurry.

SOME GEO-PHYSICAL OBSERVATIONS AT BURRINJUCK.

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With Plate LXII, and Three Text-figures.

[*Read before the Royal Society of N. S. Wales, December 1, 1915.*]

THE problems relating to the strength of the earth's crust present an attractive field of investigation alike to the mathematician, the physicist and the geologist. Such investigators as Fisher, Darwin and Love have given attention to the mathematical aspects of the question. In the realm of physics such men as Airy, Hecker and Hayford have respectively examined the problems from the standpoints of astronomy, seismology and geodesy. Among geologists, such names as Gilbert, Chamberlin and Barrell are associated with these problems.

In this communication it is desired to present a brief preliminary account of a new experimental line of investigation in this branch of science.

The State Government of New South Wales have undertaken a large irrigation scheme,[1] the reservoir for which is being constructed on the Murrumbidgee River at Burrinjuck. The dam is to have a maximum height of 236 feet, and the water to be stored is estimated at 33,000,000,000 cubic feet, a greater volume than the water contained in Sydney Harbour. The impounding of such a large mass of water, having such a great depth, will impose a certain strain on the earth's crust.

[1] For a brief account of this work see Handbook for New South Wales, published for members of the British Association for the Advancement of Science, 1914, pages 146, 147.

The opportunity which this engineering work offers for the investigation of the strength of the earth's crust was first realised by Dr. W. G. Woolnough, who was then a lecturer in Geology at the University of Sydney. He suggested that some suitable instrument be installed at the reservoir in order to ascertain whether any deflection of the earth's crust would take place under the water load; and he undertook to carry out the investigation. The Australasian Association for the Advancement of Science granted financial assistance to further the project. The subsequent appointment of Dr. Woolnough to the Chair of Geology at Perth, rendered it impossible for him to proceed with the work. Some time later, the Rev. Father Pigot, S.J., suggested to Professor David that certain pendulums which he had seen during a visit to Europe would be suitable for the investigation, and it was decided to write to Geheimrat Helmert requesting the loan of these valuable instruments. Helmert with the co-operation of Hecker and Wolf most generously arranged to lend three instruments for this investigation, which was planned to extend over a period of three years. The pendulums were shipped to the care of Professor David free of charge, and were received a few months before the outbreak of war. It is a matter for the most profound regret that the spirit of universal scientific brotherhood so well exemplified by this most generous loan has since been so conspicuously absent from the counsels of the German Government.

Two of the pendulums lent were used by Hecker (Potsdam) and Schweydar (Heidelberg) in their classical investigations on the earth tides. These instruments are of the Rebeur-Ehlert type. The third pendulum was constructed to Hecker's design and is of the Zöllner suspension type.

The care of these valuable instruments brought with it a high degree of responsibility for their safe housing and

proper installation. It was decided that if possible they should be placed in tunnels in the steep hillsides as close as practicable to the high water level of the Burrinjuck reservoir. The steep slope of the hills (about 30°) would enable the instruments to be established at a sufficient depth from the surface to minimise or eliminate the effect of surface temperature changes. The State Government generously granted the aid necessary to the preparation of these tunnels. The greatest thanks are due to the late Commissioner for Irrigation, Mr. L. A. B. Wade, for his personal interest and help in connection with this work, and also to Mr. Dare, the present Acting Commissioner, at that time Chief Engineer to the Irrigation Commission. The tunnels were driven under the supervision of the resident engineer at Burrinjuck, Mr. D. F. Campbell. This gentleman has rendered the most invaluable service both in connection with the installation and the subsequent maintenance of the instruments. It is due to his enthusiastic devotion and interest, that in spite of many difficulties, the records of the present year have yielded such satisfactory results. Thanks are also due to Mr. Goodwin for his valuable services in changing the records.

The selection of the sites for the tunnels and the installation of the instruments were carried out jointly by Professor David, Father Pigot, Mr. D. F. Campbell and the writer. The sites chosen are shown on the accompanying map (Plate LXII). The tunnels are placed from twenty to forty feet above high water level and are from sixty to eighty feet in length. Each tunnel is divided transversely into three compartments. The pendulums are housed in the compartment remote from the entrance, the lamp and photographic recording apparatus in the centre compartment, while the outer compartment serves as a storage room for accessories and as an additional protection to the

photographic records[1] in the centre chamber. This three-fold division also minimises the risk of air temperature changes affecting the instruments during visits necessary for changing the records.

Both the pendulums and the recording apparatus are mounted on solid concrete piers and are roofed over to afford a protection against water seepage and small falls of earth.

The recording apparatus[2] for two of the instruments had to be made in Sydney and the expenditure which this work necessitated was met by a further grant from the Australasian Association for the Advancement of Science. A full account of the instruments and their installation will be given in a later paper.

The first of the instruments (the Heidelburg pendulum established at Dale's Tunnel), was installed by Father Pigot in May 1914, and all three instruments were recording in October of that year. The records, however, have only been yielding satisfactory results since February 1915. Although the records obtained since that date are not sufficiently extensive to be used as a basis for a quantitative investigation, there are certain results of a qualitative nature which are of extreme interest to both geologists and geodesists. As it is proposed to continue the observations for a further period of two years before attempting a quantitative statement, the writer was requested to make such a preliminary statement as is now possible for the information of those who are interested in this research.

As a preliminary step towards the investigation it would clearly have been desirable to ascertain as far as possible,

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[1] Harrington's Limited are providing the photographic materials, and are kindly giving special attention to ensure the greatest possible speed for the paper.

[2] This recording apparatus was made by J. Cruikshank, Scientific Instrument Maker, No. 9 Nicholson-street, Wooloomooloo.

the normal stability of the earth's crust at Burrinjuck. There are two methods of attacking this problem.

The first is by obtaining a set of standard readings with the pendulums before any water load is imposed on the area.

The second method is to apply geological tests as to the stability of the earth's crust.

It has unfortunately not been possible to rigidly carry out the preliminary investigation by the first method. Owing, however, to a period of drought, and to the necessarily slow growth of the dam, the water load had not exceeded about one-sixteenth of the total load before the instruments were established. Moreover this load was maintained fairly constantly for about nine months since the first records were obtained. It is hoped that when the results are worked out, that this period will provide a sufficient test of the normal stability of the earth's crust in this area.

The second method will be investigated fully in a later paper but may be briefly outlined here.

A consideration of the topography and structural geology of the district is necessary for the solution of the problem. The Burrinjuck area is situated on a block faulted tableland, which is deeply entrenched by the Murrumbidgee at Burrinjuck. The rocks at Burrinjuck are of Devonian age, are strongly folded, and consist of slates and limestones into which are intruded granite, porphyrite and basalt. An account of the broad geological features of the reservoir area has been given by Harper.[1] The faulting is comparatively recent, and slight earthquakes have from time to time been felt in the south-eastern part of New South Wales. The most marked of these of recent years occurred in the Cooma

[1] L. F. Harper. The Geology of the Murrumbidgee District near Yass. Records Geological Survey New South Wales, Vol. IX, part 1.

and Bega area, on 18th January, 1912, at 6·9 a.m. This earthquake was felt over an area having a diameter of about 100 miles, and was recorded at the Riverview Observatory. These earthquakes indicate that crustal equilibrium has not yet been attained in this area.

The Records.

The records of each instrument from 22nd February 1915 to the 19th October of the same year are represented graphically in the accompanying diagrams. The water level is represented in each case by a curve, the ordinates of which are proportional to the actual water levels recorded at the dam.

In the case of each pendulum boom the ordinates are proportional to the actual displacements of the booms as recorded on the photographic records. The actual deflections of the vertical for each instrument for the period commencing 22nd February and ending 21st October 1915 are represented on the accompanying map (Plate LXII).

In the case of the No. 1 Pendulum (the Heidelberg pendulum established at Dale's tunnel), there was relatively little movement of the booms while the water level was slowly sinking, but both booms manifested considerable activity when the water load was increased. The sense of the movement is in the direction represented by an arrow on the accompanying map.

In the case of No. 2 Pendulum (the Strassburg Zöllner-suspension instrument, established at the Weighbridge tunnel) the deflections of the vertical are also represented on the map. The variations in the water level, however, do not exert any marked corresponding influence on the movements of the booms. This instrument is situated near the dam, and is therefore subjected to the maximum stress so far as depth of water is concerned; and hence a small rise or fall of the water level would represent only a

relatively small fraction of the total water load. The variations in water level might thus be expected to affect the booms less than in the case of either of the other pendulums.

In the case of No. 3 Pendulum (the Potsdam Pendulum established at the River Tunnel), both booms are deflected in a most marked manner. In this case also the amount and direction of the deflection of the vertical is represented on the map. This pendulum is twelve miles above the dam, and the water load is not great, being represented by a depth of about twenty-two feet of water at the commencement of the records. Small variations in the water level therefore represent large relative changes in the stresses imposed. This is consistent with the nature of the curves.

Thus in the case of each instrument there is a degree of correspondence between the movement of the pendulum booms and the variation in the water load; and this correspondence is so marked as to render a causal connection in a high degree probable.

There are at least four types of earth movements which are being recorded by the pendulums. These are

1. Earthtides. 3. Fault movements.
2. Earthquakes. 4. Slow deflections of the vertical.

The Earthtides.—As two of the pendulums were previously used for the detection of the earthtides in Europe, it was to be expected that they would record this phenomenon at their present stations. This expectation has been fulfilled.

As Burrinjuck is situated 125 miles due west from the coast of New South Wales at Jervis Bay, it is possible that the records may be slightly influenced by the load of the oceanic tides. It will be of great interest to compare the records of these instruments with those from the Standard Earthtide Station at Cobar. This station forms part of the

world scheme initiated by Hecker for the International Geodetic Association. It was established by Father Pigot at Cobar a short time before he commenced the installation at Burrinjuck. The Cobar instrument is of the Zöllner suspension type and was set up in a disused mining drive at a depth of 450 feet from the surface. As Cobar is about 360 miles from the coast it is anticipated that the effect of the oceanic tides will be quite negligible at this station. If the oceanic tides do exert a measurable effect at Burrinjuck, a comparison of the records with those of Cobar should provide a means of ascertaining the magitude of this effect. If, on the other hand, the oceanic tides exert no appreciable influence at Burrinjuck, the records will be of value in supplementing those at Cobar. Unfortunately the Cobar mine has been closed during the greater part of the past year, so that simultaneous records from Cobar and Burrinjuck are not yet available. The mine is, however, now being re-opened, and the installation of the pendulum will be shortly re-established by Father Pigot.

Earthquakes are readily recorded by all the pendulums. The periods of the booms in the different instruments vary from about eighteen to twenty-six seconds for a relatively small arc of oscillation. These records have of course no time value, as the travel of the photographic paper is only from one to three centimetres per hour; nor are the amplitudes of much value as the pendulums are undamped. Nevertheless the earthquakes are of importance in their possible relation to faulting. Earthquakes of large amplitude have on several occasions been accompanied by sudden displacements of the zero of the booms under conditions which sometimes suggest fault movements rather than instrumental errors. As a rule the earthquakes are not accompanied by displacement of the zero position of the booms.

Fault movements are represented on the records by relatively rapid movements of the booms. In most cases the movement occupies only a few hours, resulting in a permanent displacement of the zero position of both booms, these faults are generally unaccompanied by any earthquake shocks. They sometimes occur in the same sense as the preceding slow movements of the pendulum booms and at other times in the opposite direction. The position of the fault plane and the direction of the downthrow with regard to the position of the instrument no doubt determines this relation. It is hoped that the chief lines of fracture may be located by observations from all three instruments.

It is, however, in the slow deflections of the vertical that the main interest of the investigation lies. These movements may be related chiefly to the water loads or may be due to other causes, but it seems almost certain that the former cause is in operation. More light will no doubt be cast upon the problem by further investigation.

Interpretation of the Records.

It is as yet premature to offer definite conclusions, but there are certain suggestions that may be considered. Is it possible that the deflections of the vertical, which are undoubtedly taking place at Burrinjuck, are due to isostatic adjustment?

In this connection we have involved the question of local versus regional isostacy. Barrell's investigations of the strength of the earth's crust are strongly opposed to the possibility of such a relatively small mass as the water content of the Burrinjuck Reservoir having any isostatic effect. On the other hand Hayford and Bowie consider that isostatic adjustment may affect areas as small as one square mile in extent.

Is it possible that both these views may be reconciled?

In an area such as that of Burrinjuck, where the earth's crust has been proved to be fractured by many large faults, there is not that strength of the crust postulated in Barrell's investigations. Even small areas are divided in blocks by fault planes, and it is conceivable that each small area may work into a position of isostatic adjustment more or less independently of its neighbour. Conditions such as these would favour Hayford's limits for isostatic compensation in areas of this type.

If isostatic adjustment is not responsible for the deflections observed, are these to be explained by the elasticity of the earth's crust?

The instruments are certainly sensitive to small loads close to their bases of support. After spending about twelve or fifteen hours within a distance of from three to fifteen feet of the pendulums, it was found that the records always showed a gradual recovery from the strain imposed on the rock floor by one's weight. It may be that the movements of the booms are to be attributed to the water load operating in the same way. It is hoped that a quantitative examination of an extended series of records will enable the nature of the deflections of the vertical to be ascertained.

In the meantime it is certainly a matter of interest that such deflections are taking place, and that these appear to be related to the water load.

In conclusion, I would desire to express my great indebtedness to both Professor David and Father Pigot for constant advice and assistance in connection with this work; to the latter especially for his advice and guidance in completing the installations which he himself commenced but was unable to complete owing to his visit to Europe; and for his most generous help in the preparation of this paper.

Explanation of Figures and Plate LXII.

Figure 1.—Pendulum No. 1 (Heidelberg Pendulum).

The deflections of the vertical registered by both booms are represented by the changes in the ordinates of the

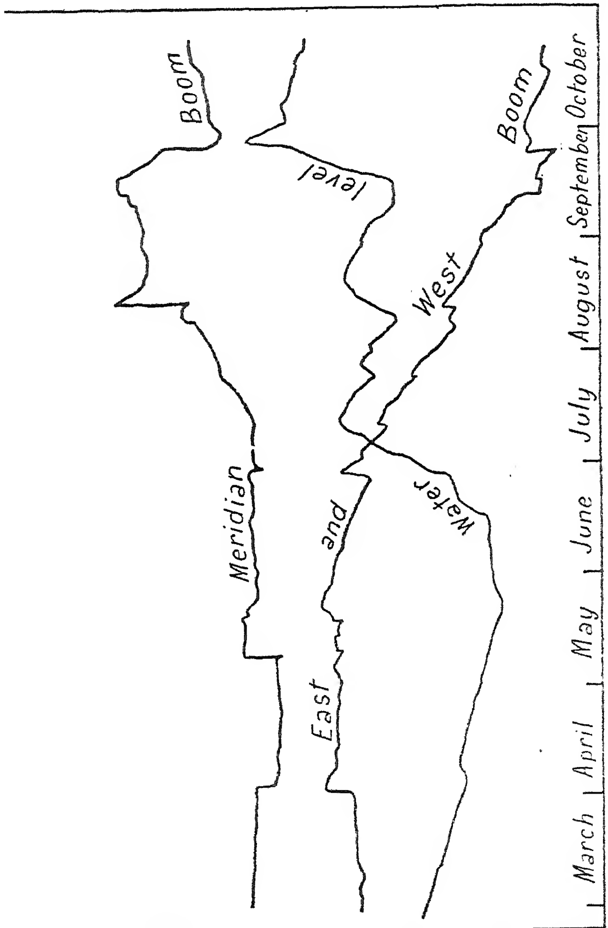

Fig. 1.

curves, which are drawn to a scale on which one centimetre represents about 1·48 seconds of arc. The amount of

deflection prior to the 22nd February is not known. In the case of the meridian boom an increase in the ordinate represents a deflection of the boom towards the east. In the case of the east and west boom a decrease in the ordinate corresponds to a deflection of the boom to the north. The curve representing the water level is drawn to a scale on which one centimetre represents twenty feet of water. The actual water level on 22nd February was fifty-two feet above the river bed at the site of this pendulum.

The abscissæ represent the times corresponding to the ordinates of the curves and are drawn to a scale of twenty days to one centimetre.

Figure 2.—Pendulum No. 2 (Strassburg Pendulum).

The deflections of the vertical registered by both booms are represented by the changes in the ordinates of the curves. These are drawn to a scale on which one centimetre represents about 0·64 seconds of arc. The amount of the deflection prior to 22nd February 1915 is not known. In the case of the meridian boom an increase in the ordinate represents a deflection of the boom towards the east. In the case of the east and west boom a decrease in the ordinate represents a deflection towards the south. The curve representing the water level is drawn to a scale on which one centimetre measures twenty feet of water. An increase in the ordinate corresponds to a rise of the water level. The actual water level at the 22nd of February, 1915, was eighty feet above the river bed at the site of this pendulum. The abscissæ of all the curves represent the times corresponding to the ordinates, and are drawn to a scale of twenty days to one centimetre.

Fig. 2.

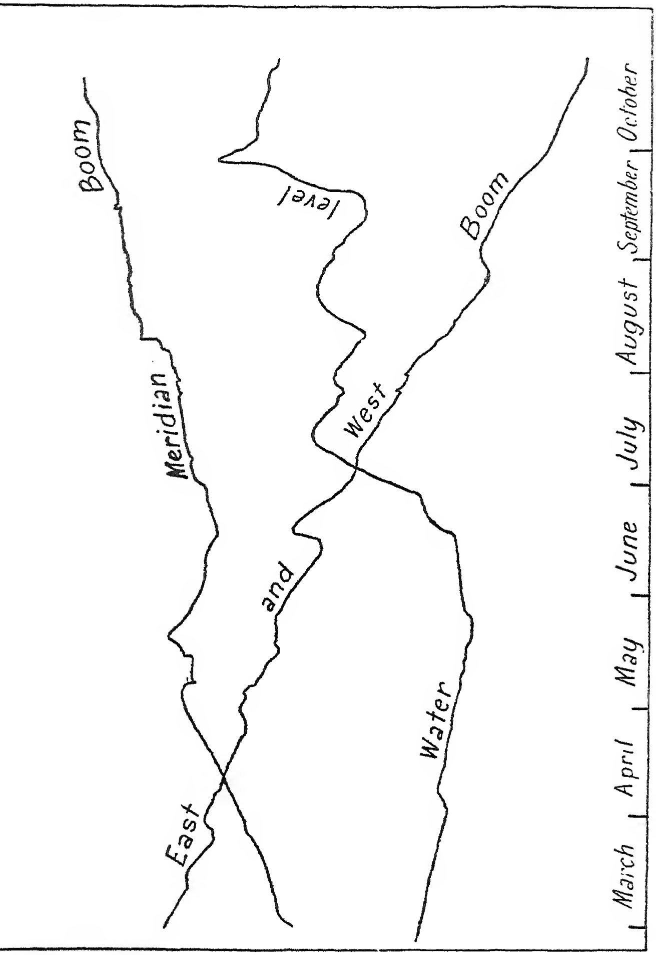

Figure 3.—Pendulum No. 3 (Potsdam Pendulum).

The deflections of the vertical registered by both booms are represented by changes in the ordinates of the curves. The curve for the meridian boom is drawn on a scale on which one centimetre corresponds to 1·74 seconds of arc.

While the curve for the east and west boom has a scale of 1·26 seconds of arc to one centimetre. The amount of deflection prior to 24th February 1915 is not known. In the case of the meridian boom an increase in the ordinate represents a deflection of the boom to the west. In the case of the east and west boom an increase in the ordinate corresponds to a deflection of the boom towards the south.

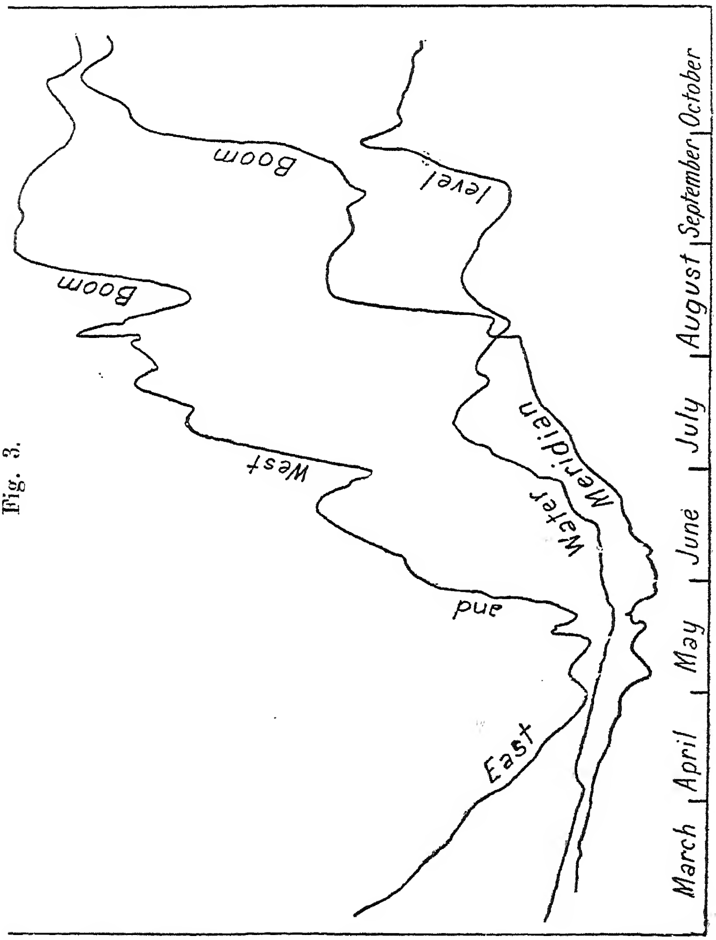

Fig. 3.

The curve of the water level is drawn to a scale on which one centimetre measures twenty feet of water. An increase in the ordinate corresponds to a rise of the water level. The actual water level at the 24th February, 1915, was twenty-two feet above the river bed at the site of this instrument. The abscissæ represent the times corresponding to the ordinates and are drawn to a scale of twenty days to one centimetre.

Plate LXII.

This map indicates the position of the Murrumbidgee River and its tributaries within the area affected by the Burrinjuck Water Conservation Scheme. The positions of the river channels are marked in firm lines, and the area which will be submerged when the dam is full is represented by the dotted lines. The three pendulums (numbered 1, 2 and 3) are situated at the intersections of the three rectangular crosses marked on the map. The deflection of the vertical for each instrument for the period, 22nd February to 21st October, 1915, is stated in seconds of arc, and the direction of the deflection is shown by an arrow marked at each station.

NOTES ON ACACIA, (WITH DESCRIPTION OF NEW SPECIES), No. I.

By J. H. MAIDEN, F.L.S.

[*Read before the Royal Society of N. S. Wales, December 1, 1915.*]

SYNOPSIS.

Introductory.

Extra-floral Nectaries (glands).

Funicle and Arillus.

Proposed New Species:—

1. *Acacia Carnei* (Pungentes—Uninerves).
2. ,, *Mabellæ* (Uninerves—Racemosæ).
3. ,, *Flocktoniæ* ,, ,,
4. ,, *Chalkeri* ,, ,,
5. ,, *Kettlewelliæ* ,, ,,
6. ,, *Clunies-Rossiæ* ,, ,,
7. ,, *Boormani* ,, ,,
8. ,, *Currani* (Julifloræ—Stenophyllæ).

Notes on Various Species:—

a. *Acacia crassiuscula* Wendl. (see under *A. Flocktoniæ*).
b. ,, *leptopetala* Benth.
c. ,, *linearis* Sims.
d. ,, *pycnantha* Benth.
e. ,, *lineata* A. Cunn.
f. ,, *imbricata* F.v.M.
g. ,, *Bynoeana* Benth.
h. ,, *ixiophylla* Benth.
i. ,, *montana* Benth.

Introductory.

I have been led to a detailed study of Australian Acacias partly because half a century has elapsed since Bentham's revision of the genus, during which period additional species have been recorded from every State in the Commonwealth,

the descriptions being published in and out of Australia, and material has accumulated in the National Herbarium of New South Wales that demanded attention. We have, in addition to New South Wales plants, some of which have been dealt with in this paper, a quantity of material from Western and Northern Australia, some of which promises to be interesting. The species from the Northern Territory are being dealt with for Professor Ewart's Flora of that area.

There is much work to be done in regard to the revision of many species, and this work, as well as the description of species deemed to be new, may, it is hoped, lead to a better grasp of the facts concerning the largest genus of Australian plants. Perhaps this work may culminate in suggested improvements in affinities and therefore of classification.

I have not absolutely correct figures in regard to Australian species, or even New South Wales; indeed, it is one of the great objects of this research to obtain evidence on these points, but the following figures are approximate:—New South Wales 128, Rest of Australia 283, Total for Australia 411 (1910). Bentham (B. Fl. ii, 1864), gave the number for Australia as 293; Mueller in 1889 (Second Census) 313.

In the Engler-Gilg "Syllabus der Pflanzen-familien" (1912) we have the estimate of the World's Acacias as 500, of which there are about 280 Phyllodineæ in Australia and the Islands.

About two-thirds of all known Acacias are Australian. Section i, (Phyllodineæ) is the largest, and is confined to Australia with the exception of a few North Australian species, which extend to Papua and some of the Pacific Islands (Greater Australia, in fact). The Acacias of all other sections have bipinnate leaves.

Section ii, Botryocephaleæ, and Section iii, Pulchellæ, are all Australian, and are far less numerous than Section i.

Section iv, Gummiferæ and Section v, Vulgares, are all African, American, or Asiatic species, with the exception of the cosmopolitan species *A. (Vachellia) Farnesiana*, which extends to Australia.

The Gummiferæ (Section iv) are especially common in North Africa, Asia Minor, Arabia, and Tropical Africa; they are the group that yield the Acacia gum of commerce, and the thorn-bushes characteristic of the African flora.

Section v (Vulgares), forms the Section next most numerous to the Phyllodineæ, and is distributed over Africa, Mexico, and Tropical America, India and Asia generally. This section is not so thorny as the Gummiferæ, and if thorns are present, they are not of stipular origin.

Section vi, Filicinæ, is a small section confined to America.

Extra-floral Nectaries (the so-called glands).

In this paper I have, in some species, drawn especial attention to the gland which, in Acacia, may be both petiolar and phyllodineous. The term gland refers to a secreting body, and is somewhat loosely used. Bentham used it in reference to Acacia (and other plants) and says "The name of glands is given to several different productions, and principally to the four following":— which he proceeds to define (B. Fl. i, xxiii). At the outset I may say that the term gland, as applied to Acacias, should be disused as unscientific, and the word nectaries used instead. A more descriptive term is "Extra-floral nectaries," but this is too long for frequent use, and hence it is probable that the term nectaries will be employed, leaving the context to explain whether the particular ones referred to are extra-floral or not. In my present paper I will continue to use the term gland for convenience.

My paper is in part a plea for more attention to be given to the gland for diagnostic (taxonomic) purposes. At the outset I am met with the following statement:—"The glands on the upper edge of the phyllodia and on the common petiole in the compound leaf seldom afford even a specific distinction . . . and I have therefore in the description seldom mentioned them." (B. Fl. ii, 301). A statement from such a source demands respect, but I think I shall be able to show that *some* glands are remarkable and characteristic. I am aware that many glands are ill-developed, and afford no special characters for description.

It is such as these that, when speaking of phyllodineous (in contradistinction to petiolar) glands, Mr. Reginald Kelly *(op. cit. infra)* states they are now "almost obliterated." One of the objects of my paper is to ask botanists to give further consideration to glands in Acacia, for it seems to me that they merit further notice.

Mr. A. D. Hardy truly says[1] that the glands of the Acacias have received but little attention, and he makes a valuable contribution to the subject. His paper is illustrated by one plate, in which the glands are not figured or described in detail, but only indicated as regards their number and position on the phyllode, which was, indeed, his object. A large number of species are referred to. At p. 30 there is a useful summary of the paper.

This paper was followed up by Mr. Reginald Kelly,[2] who dealt with the function of these glands. He joins issue with those who call them glands, and reminds us of the use of the term "extra floral nectaries" by some authors. He quotes Solederer that petiolar glands in Acacia have secretory functions; he (Mr. Kelly) found them, rarely, to be tenanted by insects.

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[1] "The distribution of leaf glands in some Victorian Acacias," (Vict. Nat. xxix, 26).

[2] "Observations on the function of Acacia leaf glands," *Ib.*, xxx, 121.

He adds that there is no evidence that the insect is a symbiont by virtue of any protection it affords. He concludes that these organs perform excretory functions, and that they are not, in his opinion, strictly speaking, glands or nectaries. He suggests the name "vents" for them. "In the phyllode they are mere relics—not yet altogether, but almost obliterated, and now functionless."

There is a valuable paper,[1] with excellent illustrations, of nectaries on both petiole and leaf, the illustrations chosen being those of the Cherry leaf and its petiole. Commencing with references to floral nectaries, the author passes on to a brief sketch of the literature of extra-floral nectaries, touching on the work of Belt and Delpino. He points out that microscopical examination of these organs at various stages shows that their development takes quite different courses in different species, and there seems no single underlying principle governing their appearance. Their secretions also vary widely, or they may be absent.

The idea that the presence of these nectaries is to divert the attention of ants from the richer nectaries in the flowers themselves (baits to insects engaged in the work of pollination) appears to have little basis in fact as far as observation goes.

It is also pointed out that in some of the broad-beans *(Vicia)*, it has been found that bees visit the extra-floral nectaries in preference to those in the flower.

But, speaking generally, the conclusion of the anonymous author is that extra-floral nectaries must be looked upon as little better than accidents in the development of the plant; they may of course have been more useful at some earlier stage in the plant's evolutionary history, but at present we can hardly avoid the conclusion, in many cases,

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[1] "Extra-floral Nectaries," Journal of Heredity, August, 1915, p. 367.

that they have no vital function, and that the plant would probably get along just as well without them. They may of course have some diagnostic value nevertheless.

I am putting my opinions to the touch by suggesting (see my remarks under *A. Kettlewelliæ*, below), that the "gland" be a character, in combination with others. When a field botanist makes up his mind that a certain plant differs from every other plant known to him, this difference may be made up of one or more outstanding characters, or it may consist of an aggregation of smaller characters. A minor character may be represented by the gland, and there is a degree of specialisation of form in this organ which should not be lightly brushed aside.

Funicle and Arillus.

Bentham (B. Fl. i, xxii) defines the *funicle* as the stalk by which the seed is attached to the placenta. It is occasionally enlarged into a membranous, pulpy, or fleshy appendage, sometimes spreading over a considerable part of the seed, or nearly enclosing it, called an *aril*. At B. Fl. ii, 302, he further defines it, and speaks of "the small fleshy aril, usually described as a strophiole." He describes some of the foldings of the funicle and adds that "All these and other modifications appear to be constant in each species, but only rarely available for specific diagnosis, for in many species the funicle is as yet unknown."

Speaking from some experience, I endorse Bentham's remarks as to the importance of the funicle, and would point out that Australian botanists have opportunities for the examination of the fresh seed that were denied to him, and I would like to interest my colleagues in this part of the subject. It is best to collect the pods when the seeds are dead ripe, then the shape, colour and lustre of the seed can be best noted, the funicle best examined, and the colour and shape of the fresh aril observed.

Within certain limits I have observed a good deal of variation in the length and folds of the funicle in the same species, but many more observations require to be made in this direction.

It is stated that the long funicle, *i.e.*, where it encircles the seed twice or thrice, is peculiar to Australian Acacias, but the precise number of species with long funicles has not been ascertained.

The following list includes most of the species with encircling or nearly encircling funicles. It will be observed that they mainly belong to the series Uninerves and Plurinerves, and mostly, though by no means inclusively, belong to regions of comparatively high rainfall:—

Pungentes (Uninerves)—*A. genistoides* A. Cunn. and *A. tetragonophylla* F.v.M.

Uninerves (Brevifoliæ)—*A. Meissneri* Lehm.

Uninerves (Racemosæ)—*A. penninervis* Sieb., *A. falcata* Willd., *A. gladiiformis* A. Cunn., *A. Wattsiana* F.v.M., *A. notabilis* F.v.M.; *A. retinoides* Schlecht., *A. Mabellæ*, n. sp., *A. rubida* A. Cunn., *A. Flocktoniæ*, n. sp., *A. amœna* Wendl., *A. Chalkeri*, n. sp., *A. Harveyi* Benth.

Plurinerves (Nervosæ)—*A. cyclopis* A. Cunn., *A. homoclada* F.v.M., *A. melanoxylon* R. Br.

Plurinerves (between Dimidiatæ and Nervosæ)—*A. oraria* F.v.M.

Plurinerves (Dimidiatæ)—*A. binervata* DC.

Julifloræ (Falcatæ)—*A. auriculiformis* A. Cunn.

Julifloræ (Dimidiatæ)—*A. cincinnata* F.v.M.

I am much indebted to Miss Margaret Flockton, Artist, Botanic Gardens, for the valuable assistance she has rendered with her drawings (not reproduced) of all the species referred to.

Proposed New Species.

Pungentes (Uninerves).

1. Acacia Carnei n. sp.

Frutex diffusus, ramis subteretibus, ramulis pubescentibus. Phyllodiis tetragonis pubescentibus, super et infra sulcatis minime profundis, angulis rotundatis. Phyllodiis rigidis vix curvatis, in apicem acrum rigidum acute attenuatis, 4 – 5 cm. longis, 1 - 1·5 mm. latis. Capitulis non numerosis, 45 – 50 floris. Calyce simile poculo formata villoso. Petalis ovato-spathulatis calycem duplo superantibus, paucis villis diffusis tectis. Pistillo villoso. Legumine non viso. Species *A. quadrisculatæ* F.v.M., proxima videtur.

A straggling shrub, with nearly terete branches, the branchlets covered with a fine tomentum.

Phyllodes tetragonous, covered with a fine tomentum, sometimes of scattered hairs. The sides of the phyllodes with shallow grooves, with rounded ridges at the angles. The phyllodes rigid, hardly curved, terminating somewhat abruptly in a sharp, rigid point, reddish-brown at the tip. Length of phyllodes 4 – 5 cm., 1 – 1·5 mm. wide or thick.

Flower-heads not numerous. Peduncles always (?) solitary, about ·5 cm., bearing each a globular flower-head of 45 – 50 flowers.

Flowers 4 or 5 merous.

Calyx cup-shaped, hairy. Petals ovate-spathulate, slightly incurved, twice the length of the calyx, clothed with a few scattered hairs; pistil hairy.

Pod not seen.

Habitat. Thackaringa, twenty-two miles from Broken Hill, towards the extreme western part of New South Wales. Joseph Edmund Carne No. 16, October 1907.

I have pleasure in associating this interesting species with the name of my old friend Mr. Carne, Government

Geologist, and that of his son Walter Mervyn Carne, one of my zealous botanical assistants, who is now in training for the defence of his country.

Affinities.

This wattle belongs to the series Pungentes, sub-series Uninerves. Of members of this sub-series I have contrasted it with *A. quadrisulcata* F.v.M., a Western Australian species to which (in absence of pods) it seems to be closest related. I have also compared it with *A. striatula* Benth., —Pungentes (Plurinerves), and also *A. gonophylla* Benth., —Calamiformes, (Uninerves), with both of which it displays some obvious superficial resemblance.

1. With *A. quadrisulcata* F.v.M. The phyllodes of this species are shorter, finer and more deeply grooved, the peduncles are longer and have only about half as many flowers in the head. The sepals are distinct, very small and narrow, linear-spathulate; petals united above the middle. It is obvious that *A. quadrisulcata* is markedly different from the new species.

2. With *A. striatula* Benth. This is another species that invites comparison, but the phyllodes are shorter and not so tetragonous, and the sepals are free, very thin and linear-spathulate.

3. With *A. gonophylla* Benth. This is another tetragonous species, but the phyllodes of *A. gonophylla* are less flattened, narrower, shorter, less rigid, and with a shorter more rigid point than the new species. The flower heads also are in pairs, and each head has only twelve to twenty flowers. The calyx lobes are narrow and the pistil smooth.

Uninerves (Racemosæ).

2. ACACIA MABELLÆ, n. sp.

Arbor umbrosa mediocriter alta, trunco usque ad 1′ diametro, surculis junioribus et rhachibus inflorescentiæ brevibus pilis aureis

tectis. Phyllodiis longis angusto-lanceolatis apice obtuso, ad 30 cm. longis et longioribus, circa 1 cm. latis. Nervis mediis marginalibusque prominentibus, lateralibus obscurissimis. Glandula non conspicua basi 1 cm. remota. Inflorescentia racemosa, capitulis circa 9 – 13 floris. Calyce corollae aequilonga, calyce truncata vel fere truncata. Sepalorum apicibus pubescentibus, petalis glabris, pistillo laeve. Legumine longiusculo latiusculoque (circa 13 × 1 cm.) subfalcato, seminibus longitudinaliter dispositis; seminis filiforme funiculo semen bis circumcingente, in clavatum arillum apice seminis terminante. Species *A. retinodes* Schlecht, proxima videtur.

An umbrageous tree of moderate height (up to 30 feet), with a trunk diameter up to a foot. Branchlets angular. The young shoots and the rhachises of the inflorescence densely covered with short, golden-yellow hairs. The bark of young growing trees is usually glaucous.

Seedling. The seedling will be described by Mr. R. H. Cambage in his papers on Acacia seedlings, but its differences from that of *A. penninervis* and *A. rubida* may be briefly stated in the following words: the young phyllodes of *A. Mabellæ* are longer and much narrower than those of the other two species, and the venation is quite distinct from either.

Phyllodes. Long narrow-lanceolate and slightly falcate. Up to 20 cm. and even longer. Width for the greater portion of the length about 1 cm. Rather thin in texture, blunt-pointed. Mid- and marginal-veins prominent, the lateral veins very faint, though visible under a lens, spreading. A not very conspicuous gland about 1 cm. from the base, the margin of which is slightly kinked at the place of the gland, and from which a rudimentary oblique vein sometimes proceeds. No stipules observed.

Inflorescence racemose, the flowers borne in profusion, of a pale yellow colour, and sweet-scented.

Flowers about nine to thirteen in the head, pentamerous, calyx and corolla of about equal length, calyx truncate or nearly so, glabrous except for the tips of the sepals, which are tufted with hairs. Petals glabrous, slightly keeled, the tips a little thickened. Pistil smooth.

Pod moderately long, and broad, (say 13×1 cm.), slightly curved. Margins of the valves thickened and somewhat grooved, the valves more or less wrinkled, the seeds arranged longitudinally, distending the valves without making the pods moniliform.

Seed with filiform funicle twice encircling it, and terminating in a clavate arillus at the top of the seed. The length and contour (whether kinked or not) of the funicle is subject to variation, as in *A. rubida*.

Synonym. A. penninervis Sieb., var. *angustifolia* Maiden in "Wattles and Wattle-barks," 3rd Edition, p. 49 (1906). It was described in the following words:—

"A long narrow-phyllode form, found only on the South Coast, so far as I know. Phyllodes commonly six inches long, and under half an inch wide, straight or slightly falcate. The pods are narrower than in the normal form. The young shoots and the rhachises of the inflorescence are sometimes densely covered with golden yellow hairs."

For a photograph of the tree see Part 50 of my "Forest Flora of New South Wales."

Habitat. Twelve to twenty feet high, Mogo about eight miles from Bateman's Bay township (W. Baeuerlen, September, 1890). Bateman's Bay (J. H. M., November, 1892). Conjola (W. Heron, September 1898, and February 1899).

"Black Wattle." Tree good for tan bark. Up to about thirty feet high. Milton (R. H. Cambage, No. 784, December, 1902; No. 4113; November, 1914; No. 4151, August, 1915).

Mr. Cambage informs me that in going south from Nowra, the Black Wattle is first met with by the roadside at about seventeen miles north of Milton. Around Milton this species avoids the most basic soils and grows on a sandy soil which is mixed with a better soil, but does not occur on the poor, highly siliceous Permo-Carboniferous formation.

I constitute the Milton specimens type of the new species, which is named in honor of my young friend Miss Mabel Fanny Cambage. The naming of a wattle after her is appropriate, because she is Honorary Treasurer of the New South Wales Branch of the Wattle Day League in connection with which she has done admirable service, and this particular wattle has associations for her in that many specimens occur on the South Coast property of her grand parents.

Affinities.

This wattle belongs to the series Uninerves and the long sub-series Racemosæ. Because of the general similarity of the structure of the flowers, *Acacia Mabellæ* has hitherto been assumed to be a form of *A. penninervis;* the seed and seedling show that it is not closely related to that species. From the point of view of the seed, with its encircling funicle, its affinity must be sought for near *A. retinodes* Schlecht., and *A. rubida* A. Cunn.

1. With *A. retinodes* Schlecht. The phyllodes of the new species are longer, the marginal veins more marked, and the lateral veins different. The lateral veins in *A. retinodes* (a Victorian and South Australian species) are more or less parallel to the mid-rib; in *A. Mabellæ* they are attached to the midrib at an acute angle.

The flowers of the new species are fewer in the head and are more squat than those of *A. retinodes*, which also have the tips of the petals recurved and the pedicels glabrous. The rhachises of the inflorescence are without the golden yellow pubescence to be seen in *A. Mabellæ.*

The pods of *A. retinodes* are narrower, but the funicles are not dissimilar.

The two species bear, however, such general and detailed resemblance to each other that it is obvious that they are closely related. At the same time I am satisfied that the species are sufficiently distinct from each other.

2. With *A. rubida* A. Cunn. *A. Mabellæ* resembles it in the seedlings and encircling funicle to the seed only. The phyllodes of *A. rubida* are much coarser, of a different colour, and they generally have a fine more or less hooked tip. They have not the pendulous appearance of *A. Mabellæ* neither is the persistent bipinnate foliage of *A. rubida* so obvious. The stems and rhachis of *A. rubida* are waxy smooth except at the extreme tips which have a yellow pubescence.

The flowers also of *A. rubida* are of a rich golden yellow, while in the new species they are of a pale whitish cream colour, and the rhachis matted with hair.

3. With *A. penninervis* Sieb. The rhachis of the new species is densely clothed with a golden pubescence; it is smooth in *A. penninervis*, though there is a tomentum of a similar character (though less copious), in the variety *falciformis* of *A. penninervis.*

The venation of the phyllodes is indistinct, but similar to that of *A. penninervis;* there is no intramarginal vein, but the edges of the phyllodes are nerve-like and the midrib prominent on both sides. There is a gland as in *A. penninervis.* The phyllodes are much longer than those of *A. penninervis.*

As regards the new species, the flowers are cream-coloured and sweet scented; those of *A. penninervis* have less odour. The petals are five or six in number, glabrous, broader than those of *A. penninervis*, and much more frail in texture.

The seeds of the new species have a double funicle completely surrounding them; those of *A. penninervis* have a shorter funicle. Bentham (B. Fl. ii, 362) says, "funicle long, dilated and coloured nearly from the base, extending round the seed and bent back on the same side, so as to encircle it in a double fold."

I have not been able to confirm Bentham's observations in this respect. In the specimens belonging to the typical form that I have been able to examine, the funicle has hardly extended half round the seed. In var. *falciformis* I have observed funicles that I cannot distinguish from those of the normal form and, in addition, doubly folded funicles extending more than half way round the seed, but never doubly encircling funicles as in *A. Mabellæ*.

The seedlings of the two species may be briefly contrasted as follows:—the phyllodes of the former are shorter and very much broader and have a distinct venation.

Uninerves (Racemosæ).

3. Acacia Flocktoniæ n. sp.

Frutex gracilis 6 – 12′ altus, habitu debile pendulo, ramulis teretibus glabris. Phyllodiis lineari-lanceolatis, 6 – 8 cm. longis, circa 3 mm. latis, in apicem acutum attenuatis, basin versus angustatis, nervo principale medio paullo remoto, glandula basin versus phyllodiæ. Floribus in racemis folia superantibus, rhache glabro, capitulis 25 – 30 floris, calyce turbinata paullo lobata, angulata, glabra praeter angulos et apicem. Petalis glabris, sepalis dimidio aequilongis, pistillo glabro. Legumine stipitato, valvarum marginibus paullo incrassatis, plano plerumque recto, 6 – 11 cm. longo 6 mm. lato, valvis inter semina contractis sed non moniliformibus, seminibus longitudinaliter dispositis, funiculo semen bis vel saepius circumcingente. Species *A. rubidæ* A. Cunn., proxima videtur.

The over-used name *Acacia crassiuscula* has long had a fascination for me; it has been applied by different botanists to at least four different plants, viz:—

(*a*) By Wendland to a presumably Western Australian plant which is now usually attributed (and I think correctly) to *A. pycnophylla* Benth. (B. Fl. iii, 368). The same plant was also called *crassiuscula* by Meissner.

(*b*) By Sieber[1] to a New South Wales plant which I have nce named *A. obtusata* Sieb. var. *Hamiltoni*. It is Sieber's No. 464.

(*c*) By Allan Cunningham[2] to a New South Wales plant made by him a variety of his *A. adunca*.

(*d*) In B. Fl. iii, 372 the *A. crassiuscula* Wendl., probably covers several species. It should be called *A. crassiuscula* Benth., and I am satisfied that Bentham's description applies more or less to more than one species.

A. adunca A. Cunn., has already been referred to.

It will be observed that Bentham refers *A. crassiuscula* to Queensland, New South Wales, and Tasmania. Let us examine some of the plants referred to by him under the various States.

1. *Queensland*—Fitzalan's Moreton Bay specimen I have not seen. Bailey ("Queensland Flora") contents himself with repeating Bentham's statements in the "Flora Australiensis." Certainly there is no *A. crassiuscula* in Queensland and what Fitzalan's plant is should be enquired into.

2. *New South Wales*—Sieber's No. 464 I have already referred to. Robert Brown's Port Jackson to Blue Mountains specimen I have been trying to trace home for many years with the following result.

[1] See my "Forest Flora of New South Wales," Vol. v, pp. 114 and 153.

[2] *Ib.*, p. 114.

I received a piece of the original from the late Mr. J. G. Luehmann of the Melbourne Herbarium, in 1898, labelled, "*Acacia crassiuscula* Benth. non Wendl. (*A. lunata* Sieb. Mueller's addition). Banks of the Nepean River, Robert Brown (1802-4)."

I carried a portion in my pocket book for years, but failed to match it in my wanderings. It is in flower only. On a special occasion (September 1906) Mr. R. H. Cambage and I accepted the hospitality of the Hawkesbury Agricultural College, got a rowing boat, searched the banks of the Nepean in the vicinity, and also of the Grose River (which we know Robert Brown ascended), but could not find the wattle. Later on (1909) Mr. Cambage collected the plant at Yerranderie, but it was only recently that I identified it with Brown's plant, and it proves to be new. Specimens of Bentham's further record of "barren brushy hills of the Blue Mountains" (Cunningham and Fraser) I have not seen, but I find I collected the wattle at Mount Victoria in December, 1896. I do not remember the precise part of Mount Victoria, but it will give a clue as to where Cunningham and Fraser found it.

3. *Tasmania*—Flinders' Island, Bass' Straits (J.D. Hooker).

Bentham follows Hooker (Flora of Tasmania, p. 108) in this matter. *Loc. cit.*, Hooker quotes Gunn's 1957 for *A. crassiuscula*, and I have a specimen before me. It is Joseph Milligan's No. 581 and was collected 6th March, 1845, and is labelled "Flinders' Island at Establishment." What this locality means, may be seen from my notes on Dr. Milligan's career in Proc. Roy. Soc. Tas. for 1909, p. 22. He superintended the removal of the aborigines from Flinders' Island to Oyster Cove in 1848.

It is a poor specimen, and I have a better one, in bud only, without fruit, from Archer's Herbarium. The material may be described as follows, and it slightly supplements

Hooker:—Gland of phyllode near base. Flowers twenty-three in the head, 5 or 6-merous. Calyx turbinate, hairy at the apex. Petals glabrous, free, thickened at the top. Pistil hairy.

I hope that someone will re-collect the plant from the vicinity of the site indicated in Flinders' Island. My material is not sufficient to say if it is a species hitherto recorded from Tasmania, but it is not *A. crassiuscula* Wendl., which should be removed from the flora of Tasmania. The linear pods should be collected.

Mr. W. V. Fitzgerald makes a contribution[1] to the "crassiuscula" confusion. He says that to *A. crassiuscula* Wendl., "should be referred *A. subbinervia* Meissn., and Bentham's *A. crassiuscula* and *pycnophylla*."

I have a portion of Preiss' No. 924 before me, which is in flower only, and is the type of *A. subbinervia* Meissn. I do not know what evidence there is to upset Bentham's conclusion (B. Fl. ii, 368) that *A. subbinervia* is a synonym of *A. rostellifera* Benth.

As to *A. crassiuscula* Benth. being a synonym of *A. crassiuscula* Wendl. I have abundantly shown the contrary, nor was I the first to do so.

* * * * * *

I will now proceed to describe Robert Brown's "Port Jackson to Blue Mountains" specimen, or to be more precise, the Yerranderie plant with which I have identified it.

A slender shrub of six to twelve feet high, of weak, pendulous growth, with few branches, and these usually borne towards the ends of the stems. It has something of the habit of *A. linifolia* Willd. Branchlets rounded, angular towards the tips, glabrous.

Phyllodes linear-lanceolate, gradually tapering from the middle towards the apex and the base, 6–8 cm. long and

[1] Journal W. A. Nat. Hist. Soc., No. 1, Vol. II, p. 49 (May, 1904).

about 3 mm. broad, the apex forming a sharp point, which is rarely hooked. Texture thin, the principal vein usually not situated along the middle of the phyllode, but a little from the median line: lateral veins few and inconspicuous. No stipules observed. Very small gland near the base of the phyllode.

Flowers bright yellow, often borne at the ends of the branchlets, in racemes, exceeding the leaves. Rhachis glabrous. The individual flowers are very frail and transparent in texture. They are 25–30 in the head.

Calyx turbinate, slightly lobed, angled, the sutures of the sepals well marked, glabrous except on the angles and at the top, sepals about two-thirds the length of the petals.

Corolla. The petals are glabrous, half the length of the sepals.

Pistil glabrous.

Pod stipitate, margin of the valves slightly thickened, flat, usually straight, sometimes curved, 6–11 cm. long, and 6 mm. broad. Valves constricted between the seeds, but not moniliform.

Seeds arranged longitudinally in the pod. The funicle encircling the seed twice or more, and terminating in a white slightly swollen club-shaped aril towards the top of the seed.

Habitat. I have specimens from—

1. Banks of the Nepean River, N.S.W., (Robert Brown, 1802-4). In flower.
2. Mount Victoria (J. H. M., December, 1896). In flower.
3. Six to eight feet high, Byrnes' Gap, Yerranderie on Permo-Carboniferous formation, (R. H. Cambage, No. 2188, 7th June 1909). In flower.
4. Same locality and collector, No. 2189. A narrow leaved form of No. 2188.

5. Same locality and collector, No. 3126 (2nd December, 1911). In fruit.

6. Six to twelve feet, Yerranderie, (J. L. Boorman, July, 1915). In flower.

So that the range at present ascertained can be stated as Mount Victoria, thence due south for about forty miles as the crow flies to Yerranderie. The Nepean River locality cannot be traced.

I constitute the Yerranderie specimens the type. Named in honour of Miss Margaret Flockton, the talented artist of my "Forest Flora of New South Wales," "Critical Revision of the Genus Eucalyptus" etc., who adds to her artistic skill the capacity of working out botanical points in a most intelligent manner.

Synonyms—*A. crassiuscula* Benth., non Wendl., (in part). *A. lunata* Sieb., var. *crassiuscula* Maiden and Betche, in Maiden's "Wattles and Wattle Barks," 3rd Edition, p. 82 (excluding the Tasmanian reference).

Affinities.

1. With *A. rubida* A. Cunn. In such an important character as the double-encircling funicle of the seed, *A. Flocktoniæ* seems to be closest allied to what I may term the "*Acacia rubida* group" (I will define what species I propose to place in this group in a later paper). From *A. rubida*, perhaps its nearest ally, it is separated by the larger, gland-indented phyllodes of *A. rubida*, the more hairy flowers, of somewhat different shape.

2. With *A. adunca* A. Cunn. This is a species, figured at plate 173 of my "Forest Flora of New South Wales." It is one of the species brought into the "Crassiuscula" confusion as already explained. It and *A. Flocktoniæ* are sharply separated in phyllodes and seeds (which have non-encircling funicles in *A. adunca*) and, to a less extent, in flowers.

3. With *A. lunata* Sieb. I mention this because Mueller first suggested the affinity, and the late Mr. Betche and I followed him. He and we had only the flowers (and the affinity of these is not very close), but discovery of the seeds shows that the two species are sharply separated, *A. lunata* having a short non-encircling funicle terminating in a fleshy aril on the top of the seed.

Uninerves (Racemosæ).

4. ACACIA CHALKERI n. sp.

Frutex dumosus circa 6′, ramulis angulatis. Phyllodiis oblanceolatis, apice breve mucronata, ad 4·5 cm. longis et 9 mm. latis. Inflorescentia racemosa phyllodios non superante, capitulis non numerosis circa 18-floris. Calyce paullo corolla longiore, corollae apice brevibus pilis fimbriata, petalis glabris, pistillo laeve. Legumine fere plano rectoque circa 7 cm. longo 7 mm. lato, seminibus longitudinaliter dispositis. Funiculo semen bis circumcingente, in arillo clavato terminante.

Species *A. retinodes* Schlecht., et *A. rubidæ* A. Cunn., affinis videtur.

A small bushy shrub of about six feet, with angular branchlets.

Phyllode. Oblanceolate, the apex with a short mucrone, which is sometimes turned a little on one side. Up to 4·5 cm. long and to about 9 mm. in its widest part. Tapers gradually into the point of attachment to the branchlet. Margin slightly thickened, midrib distinct, lateral veins attached to the midrib and almost feather-veined. A gland a little way up the phyllode, but the phyllode is not constricted or bent at the place of the gland.

Inflorescence racemose, not exceeding the phyllodes. No stipules observed.

Flowers about eighteen in the head, heads of flowers not numerous. Calyx a little longer than the corolla, fringed

with short hairs at the top. Petals glabrous. Pistil pale green when fresh and very smooth.

Pod. Nearly flat and straight, slightly constricted between the seeds, which are disposed longitudinally. About 7 cm. long and 7 mm. broad.

Funicle thread-like; at the end of the first kink it is sharply bent and twice encircles the seed, finally terminating in a club-shaped arillus.

Habitat. Wombeyan Caves, N. S. Wales, on the limestone, (R. H. Cambage, E. C. Andrews and J. H. Maiden, October, 1905). The only known locality at present.

Named in honour of Mr. Thomas Michael Chalker, Caretaker of Wombeyan Caves.

Affinities.

It belongs to the series with the funicle twice encircling the seed, and hence it is related to *A. retinodes* Schlecht., and *A. rubida* A. Cunn.

1. With *A. retinodes* Schlecht. The phyllodes are very different, being linear lanceolate and much longer; the funicles are not dissimilar; the flowers are somewhat similar, but usually hexamerous in *A. retinodes*, while sometimes pentamerous.

2. With *A. rubida* A.Cunn. It has resemblances in regard to the funicle and arillus. It also agrees in the truncate calyx and smooth pistil, but the foliage of the two species is very different.

3. With *A. amœna* Wendl. *A. amœna* differs in the flower, the calyx-lobes separating to the base in the *pistil* which is hairy, and in the seed with encircling funicle more than twice round, but this is a somewhat variable character.

The phyllode of *A. amœna* has two or three very prominent glands and is of a very different shape to that of the new species.

4. With *A. prominens* A. Cunn. A much larger plant, with the gland much larger and placed higher up the phyllode and the funicle very different.

5. With *A. obtusata* Sieb. The two species differ in the funicle and also in the pod, both being very different. The flower is somewhat similar, so also is the phyllode.

Uninerves (Racemosæ).

5. Acacia Kettlewelliæ, n. sp.

Arbor parva ad 20′ alta, foliis argenteis ramulis angulatis. Phyllodiis oblanceolatis paullo falcatis 6 – 8 cm. longis, 6 - 8 mm. maxima longitudine, glandula pulchra conspicua "Weaver-bird" nido simile. Nervo medio prominente, nervis lateralibus patentibus. Floribus in racemis densis phyllodios vix superantibus, capitulis globosis circa 10-floris. Floribus 5-meris, rhache glabra. Calyce late conoidea, subangulata, brevibus pilis sparsis. Calycis lobis petalis aequilongis. Petalis glabris liberis paullo incurvatis, pistillo laevo nitente. Legumine plano glauco, seminibus longitudinaliter vel oblique raro transverse dispositis. Semine funiculo breve filiforme in arillum albidum pulvino similem seminis apice terminante. Species *A. prominenti* Willd. proxima videtur.

A tall shrub or small tree up to twenty feet high, with silvery foliage and angular branchlets.

Phyllodes oblanceolate, slightly falcate, the marginal vein on the ventral side bent in, where there is a remarkable gland about two-thirds of the way to the insertion of the phyllode. Midrib prominent with lateral veins spreading. From 6 – 8 cm. long and 6 – 8 mm. in greatest width. No stipules observed.

The large gland on the margin is reminiscent of a weaver bird nest, and is the first I have noticed of this precise shape. It is a beautifully constructed gland, with the mouth opening downwards. At page 466 I have suggested

that examination of the glands in Acacia should be given more attention in future.

Flowers in dense racemes, scarcely exceeding the phyllodes; in globular heads, flowers five-merous, about ten in the head. Rhachis glabrous.

Calyx broadly conoid; slightly lobed, the length of the calyx-lobes about equal to that of the petals. Somewhat angular, besprinkled with a few scattered hairs.

Petals glabrous, free, slightly incurved.

Pistil smooth and shiny.

Pod flat, glaucous, more or less netted, veined, when ripe the edges of the valves with a narrow raised rim, the seeds disposed longitudinally or obliquely and occasionally transversely.[1]

Seed with a rather short filiform funicle terminating in a cushion-shaped white arillus at the top of the seed.

The type is from St. Bernard's Hospice to Harrietville, Victoria, (R. H. Cambage's No. 3714, 18th January, 1913). It is in fruit only and the flowers have been described from Buffalo Mountain, Victoria (Charles Walter, October 1902). I have it also in fruit from Buckland River, Buffalo Mountains (C. Walter, January 1899); I should have made this the type, but the specimen is so sparse that I cannot divide it. Also in fruit from Mrs. T. McCann, Snowy Creek, New South Wales, viâ Tallangatta, Victoria.

I have it in the youngest stage of bud, or in phyllodes only, from Thredbo River, Jindabyne, New South Wales (W. Baeuerlen, February 1890); Mount Kosciusko, N. S. Wales up to 5,500 feet (J. H. M., January 1898); Jindabyne (J. H. M. and W. Forsyth, January 1899); Mount St. Bernard, the type locality (J. H. M., January 1900); Back Creek, Tumbarumba (R. H. Cambage, No. 861, March 1903).

[1] I emphasise this as showing that the position of the seed in the pod in Acacia varies like every other character.

I dedicate this species in honour of Mrs. Agnes Kettlewell who, with Mrs. Clunies-Ross and myself founded the Wattle Day League, who was the first Honorary Secretary of the Sydney Branch and who still remains in office.

Affinities.

1. With *A. prominens* A. Cunn. This new species comes very near to *A. prominens*, but has a longer and narrower phyllode with a quite different gland, which has the orifice at the top, and descending, instead of in the middle of the gland as in *A. prominens*. In the new species there is generally a narrowing of the phyllode where the gland occurs, until the gland touches the midrib.

The flowers in both species are nearly glabrous, with scattered hairs on the calyx, but in the new species the calyx is more angular and the petals more or less constricted where they meet the top of the calyx. The seeds are alike in both species.

2. With *A. Clunies-Rossiæ* Maiden. The two species are separated by the tomentum of the phyllodes in *A. Clunies-Rossiæ*, and the very different shapes of the glands. The structure of the flower is very different in the two species, the shape of the calyx and the relative proportions of its parts to the corolla, being marked and fundamental.

I am much obliged to my assistant, Mr. E. Cheel, for useful criticism in regard to this species.

Uninerves (Racemosæ).

6. Acacia Clunies-Rossiæ n. sp.

Frutex 15′ vel altior. Phyllodiis fere oblanceolatis, subfalcatis, plerumque apice fere curvata, apicibus juvenibus exalbidis brevibus pilis argenteis. Phyllodiis 4 – 5 cm. longis, 5 mm. – 1 cm. latis, nervo nedio distincto paucis nervis lateralibus obscuris. Glandula unica reniforme phyllodiae basin versus. Capitulis in racemis phyllodios non superantibus, circa 9-floris, rhache pilosa.

Calyce obtuse spathulata, sepalis circa dimidio petalis aequilongis liberis vel fere liberis, parte superiore pilosa. Petalis cymbae similibus formatis, glabris paullo carinatis, pistillo omnino glabre. Leguminibus planis rectis vel sub-falcatis, circa 7 cm. longis 7 mm. latis, maturis non visis, glaucis, valvarum marginibus incrassatis. Seminibus leguminis medio longitudinaliter dispositis. Funiculo duabus plicis in arillum carnosum clavatum lateralem terminante seminis apicem partim circumcingente.

Species *A. prominenti* Willd. proxima videtur.

A tall dense, pale foliaged shrub of fifteen feet high or more with rounded hoary branchlets, angular towards the tips.

Phyllodia slightly oblanceolate, slightly falcate, usually with a slightly hooked point, the young tips nearly whitish, through the presence of an abundance of short silvery hairs, the rest of the phyllode uniformly but more sparsely covered with similar hairs, which are almost absent in very old phyllodes. Length 4–5 cm., width about 5 mm., up to fully 1 cm. in young phyllodes.

A distinct midrib, a few lateral spreading veins scarcely visible except with the aid of a lens. No stipules observed.

One almost reniform gland near the base of the phyllode, perhaps a quarter of the way up, the margin of the phyllode scarcely bent or recessed at the gland-place.

Flowers in racemes, not exceeding the phyllodes. Buds nearly spherical, about nine in the head; rhachis hairy.

Calyx bluntly spathulate, the sepals about half as long as the petals; free to the base, or nearly so, besprinkled with hairs on the upper part.

Corolla petals boat-shaped, glabrous, with a slight keel.

Pistil quite glabrous.

Pods not seen quite mature, flat, straight or oftener slightly curved, about 7 cm. long by 7 mm. broad, glaucous, rims of the valves thickened.

Seeds longitudinally arranged in the centre of the pod. Funicle almost thread-like to the first kink, then a short slightly broader expansion to another kink, then a fleshy, clavate, lateral aril partly encircling the top of the seed.

Habitat. Near the Kowmung River, close to Yerranderie, N. S. Wales. The locality is in the southern highlands, about thirty miles in a direct line westerly of Camden. It is the only locality known at present. All collected by R. H. Cambage, and the numbers and comments (in inverted commas) are his.

1. "Like *A. prominens.* Devonian quartzite 2,000 feet. Kowmung (River), Yerranderie, N.S.W., 7th June, 1909, (No. 2743. I fully believe this to be the same as No. 2296)." Phyllodes only.

2. "Kowmung River, Yerranderie, 6th October 1909, (No. 2296)." In flower.

3. "Towards Kowmung, 2nd December, 1911, (No. 3129; same as 2296). Foliage of young tree, eight feet." Young phyllodes only.

4. "Fifteen feet high. Towards Kowmung, 2nd December 1911, (No. 3128; same as 2296)." Phyllodes and nearly mature pods.

5. "Foliage of young trees, six to eight feet. Towards Kowmung, 2nd December 1911, (No. 3127)." Phyllodes only.

I dedicate this species in honour of Mrs. Elizabeth Clunies-Ross who, with Mrs. Kettlewell and myself, founded the Australian Wattle Day League in the year 1909, and who was, for some years, Honorary Treasurer of the Sydney Branch. It also commemorates her late husband, an esteemed member of this Society for many years and a Vice-President of the League.

Affinity.

With *A. prominens* A. Cunn. This seems its closest affinity. The phyllodes of *A. prominens* are broader and

free from hairs, the gland of that species is different in shape, and projects beyond the margin of the phyllode. The sepals of *A. prominens* are united for the greater part of their length and the tips of the petals are markedly thickened. The pods of *A. prominens* are broader and the seeds are arranged transversely in the pod, but the funicle and arillus are not dissimilar in the two species.

Uninerves (Racemosæ).

7. Acacia Boormani n. sp.

Frutex debilis erectus, nitore argenteo distinguente. Ramulis subangulatis glabris. Phyllodiis angusto-linearibus, circa 3 cm. × 2 mm., uno nervo haud prominente, apice saepe falcata curvataque. Racemis phyllodias vix superantibus vel brevioribus, capitulis breve pedunculatis circa 7 floris. Floribus 5-meris. Calyce patente, angulata fere hemisphærica, prope truncata, sepalorum apicibus paullo pilosis. Corolla calyce bis aequilonga, petalis latiusculis, glabris, basi disjungentibus, saepe imbricatis. Staminibus filamentis brevibus. Pistillo glabre, fructu non viso. Species *A. linifoliæ* Willd. proxima videtur.

A weak upright-growing shrub somewhat denuded of leaves at its base, but becoming very leafy towards the head. Branchlets subangular and glabrous. It grows to about nine to ten feet high in some localities, but is usually three to five feet high. Stems smooth, not seen above an inch in diameter. It forms numerous sucker growths. It is exceedingly floriferous, but, like some other species that propagate themselves vegetatively, is shy to set its fruit, and I have not yet obtained fruits although they have been diligently sought for. The whole plant has a distinctive silvery lustre which affords a ready means of distinguishing the plant from all other species in the district.

Phyllode. Narrow-linear, not long (about 3 cm. × 2 mm.) with one not very prominent nerve; often with a bent, sometimes hooked point. The lower portion of the phyllode

slightly tapering to the point of attachment. A not very conspicuous gland rather low down on the phyllode. Minute lanceolate stipules observed in the phyllodes when the flower-buds are very young.

Flowers. Racemes scarcely exceeding the phyllodia or shorter. Inflorescence golden yellow. Buds nearly spherical. Heads of flowers shortly stalked. About seven flowers in the head, 5 or 6-merous.

The calyx spreading, angled, nearly hemispherical, almost truncate (*i.e.*, the lobes of the calyx very blunt), the tips of the sepals slightly hairy.

The corolla twice as long as the calyx, the petals broadish, glabrous, separating to the base, where they are strongly united; often imbricate, which is very unusual.

The stamens with short filaments.

The bracts at the base of the flower of a bright red-brown when quite fresh.

Pistil glabrous.

Fruit not seen.

Habitat. Shrub about four feet high, in early bud. Slate formation, Cowra Creek, near Cooma, (Macanally Range) N.S.W. (R. H. Cambage, No. 1878, 10th February, 1908).

In bud a little more advanced. The glaucous character of the buds is very evident. Banks of the Snowy River at Tombong, near Bombala (W. Forsyth, May 1908). In flower (R. Bornstein per R. H. Cambage, No. 1878a, September, 1908. Identical with 1878 above). In flower. Fairly plentiful on the sides of Mount (Macanally) and *en route* to the Macanally Mines (J. L. Boorman, 25th September, 1913). Mr. Boorman also collected it in December, 1914, when it was past flowering, but no pods could be obtained. With the exception of the Tombong specimens, all the specimens came from the same district, which may be

referred to as the Macanally Range, fifteen to twenty miles from Cooma. The Tombong locality is fifty miles to the south. Between Tombong and the Macanally Range is the course of the Snowy River, and the species will doubtless be found along its course.

I have chosen the specimens J. L. Boorman, 25th September, 1913, as the type, because I have adequate material of it, and name the species in honour of John Luke Boorman, Collector on the staff of the Botanic Gardens, Sydney.

Affinities.

Its affinities must be uncertain until such time as the pods are available, but I have waited over seven years for them, and feel, after due consideration, that the species is undescribed.

1. With *A. linifolia* Willd. *A. linifolia* has the phyllodes more sparse, the flowers fewer in the head, and the peduncles and pedicels longer. The corolla is proportionately longer than the calyx. The inflorescence of *A. linifolia* is cream-coloured, not yellow; the plant is more wand-like. Variations in the phyllodes appear to be owing to environment; I do not notice any fundamental differences in these organs.

A. Boormani is a plant of cold regions (Monaro); *A. linifolia* comes from warmer localities, the Hunter to the Picton districts. Nevertheless, in the present state of our knowledge, it would appear that *A. Boormani* comes closest to *A. linifolia.*

2. With *A. decora* Reichb. A good deal of the northern New South Wales material of this species has very narrow phyllodes, (*Cf.* figs. L and M of plate 169 of my "Forest Flora of New South Wales,") but the shape of the phyllodes and the structure of the flower are different.

Juliflorae (Stenophyllae).

8. Acacia Currani n. sp.

Frutex videtur, ramulis longis tenuibus subteretibus, pilis sericeis mollibus tectis. Phyllodiis 12 - 17 cm. longis linearibus obtuso-acutis, planis striatis pallido sericeo tomento pilorum dispersorum. Floribus pentameris, calyce fere ad basem lobata infra vix constricta, parte superiore pilosa, inferiore sparse pilosa. Pistillo parte superiore pilosa, inferiore sparse pilosa. Leguminibus rectis 4 – 6 cm. longis 3 – 4 mm. latis, pilis albis dense tectis, pedunculis pedicellisque pariter pilosis. Seminibus longitudinaliter dispositis, funiculo circa semen bis plicato, plica una breve altera longa. Species *A. Burkittii* F.v.M. proxima videtur.

Apparently a shrub with long wisp-like roundish branchlets, slightly compressed towards the tips. Silky-downy all through, except on the old wood.

Phyllodes long (12 to 17 cm.), linear, blunt pointed, flattish, striate, with a pale silky tomentum of scattered hairs. Rhachis densely matted in hair. Stipules not observed.

I have not seen a complete spike of flowers, although Mueller, ("Iconography of Australian Acacias," under *A. cyperophylla*, left hand figure), figures spikes which are shortly stalked, are barely 1 cm. long, and which may be intended for *A. Currani*.

All the specimens that I have seen are a mat of over-ripe flowers, but Mueller, by placing it on the *A. cyperophylla* plate assumes that it is spicate; (spikes short and about three times as long as broad; he figures it pedunculate in the enlarged details).

Flowers pentamerous; the various parts of the flower are glabrous or nearly so at the bases, and get increasingly hairy towards the tops.

Calyx lobed nearly to the base, hardly constricted below, hairy on the upper half, very sparsely on the lower half.

Petals united two-thirds of the way up, hairy on the upper half, very sparsely on the lower half.

Pistil hairy on the upper half, sparsely hairy on the lower half.

Bracts large, coarse, some of them bent, and all covered in hair.

Pods stipitate, straight, 4 – 6 cm. long, 3 – 4 mm. wide; covered with a mat of white hairs, the stem also, but not matted. The peduncles and pedicels are also hairy.

Seeds longitudinally arranged in the pod; the funicle folded twice round the seed, in a long and a short fold.

Habitat. Cobar, N.S. Wales (Rev. J. Milne Curran, F.G.S.). So far as I know, only two specimens are in existence and they are in the Melbourne Herbarium.

1. Is labelled (*A. cyperophylla* by Mueller), and "Cobar N.S.W., Rev. Milne Curran, 1887." It is in pod and has over-mature flowers.

2. It is further labelled "Acacia No. 308. Bark peels off portion enclosed (not available, J.H.M.) with remains of withered flowers."

The label of specimen No. 2 is in Father Curran's handwriting, which I know well. Nos. 1 and 2 are identical in origin, though whether sent at the same time I do not know. I wrote to Father Curran for further particulars of the plant, and for additional material but, owing to his absence from Sydney, I have had no reply.

I then wrote to the Ven. Archdeacon Haviland, now of Cobar, formerly of Bourke, and an authority on the plants of both places. He replied, "I am at a loss to know where he (Father Curran) could have got it; I am pretty well certain it was not in either Bourke or Cobar districts."

This introduces an element of doubt into the locality, but it was not stated how near the township at Cobar the

specimen was obtained, and as special attention has only been drawn to this plant by me, and it could easily have been passed over in the bush for other plants, particularly when not in flower, all that remains is to be on the look out for it.

Affinities.

The affinity of this new species appears to be closest to *A. Burkittii*, but the final word in classification cannot be said until fresh spikes of flowers are available. At present, judging from the pods, it would appear that the spikes are arranged in a racemose manner, and that they are pedunculate.

1. With *A. Burkittii* F.v.M. It is sharply separated from *A. Burkittii*, which is glabrous. The phyllodes of *A. Burkittii* are more rigid and more terete. The heads of flowers in *A. Burkittii* are in pairs. The seeds are different.

2. With *A. cyperophylla* F.v.M. Let us examine the plate of *A. cyperophylla* F.v.M. in Mueller's "Iconography of Australian Acacias, etc." The plate consists of three twigs, and it is a remarkable statement for me to make that each twig is probably a different species.

(a) The central twig is typical *A. cyperophylla* F.v.M., and I will explain matters in Part 60 of my "Forest Flora of New South Wales."

(b) The right hand twig is *Acacia Currani* Maiden, and most (probably all) of the analytical drawings belong to that species.

(c) The left hand twig is probably *A. Burkittii* F.v.M. (the "portions of phyllodia" alongside belong to *A. Currani*). One cannot speak with certainty because the drawing does not enable one to do so.

Notes on Various Species.

a. ACACIA CRASSIUSCULA Wendl.

(See under *A. Flocktoniæ* supra, p. 477.)

b. ACACIA LEPTOPETALA Benth. (Syn. A. MURRAYANA F.v.M.)

I concur in Bentham's observation that *A. Murrayana* differs "from *A. leptopetala* in little besides the long narrow phyllodia."

This dry country wattle has now been found in a number of New South Wales localities. Mr. W. A. W. de Beuzeville, in recently sending it from Wambaduli, Pilliga, remarks "the bark is rather peculiar, being of a mealy white appearance; the only other Acacia that I have seen with a bark at all similar is *A. spectabilis*. I may remark that the Western Australian plants of *A. leptopetala* are similarly glaucous.

c. ACACIA LINEARIS Sims.

Hooker, in recording it[1] from Tasmania, says "This appears to be a very rare Tasmanian plant, and has never been found in fruit. Mr. Gunn, who alone has gathered it, says that he has seen a very few bushes of it, which have since been burnt down; and as the place where they grew has been fenced in, and turned to a pasturage, it is probable that it will become extinct there."

I have a specimen of Gunn's No. 677, which is the plant referred to by Hooker; it is labelled "C.Hd" (Circular Head) and was collected in the year 1837. I have carefully examined this specimen and do not see in what detail it differs from *A. suaveolens* Willd., and recommend that Hooker's record of *A. linearis* for Tasmania be withdrawn.

Mr. L. Rodway records[2] *A. linearis* from George's Bay, Tasmania, and also makes the interesting suggestion that it constitutes a variety *(linearis)*, of *A. mucronata* Willd. I have dealt with *A. mucronata* in Part 57 of my "Forest Flora of New South Wales" now in the press.

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[1] "Flora of Tasmania," I, p. 109. [2] "The Tasmanian Flora," p. 42.

What I have seen from Tasmania attributed to *A. linearis* has phyllodes 3 – 4 cm. long, instead of the phyllodes of 8 – 13 cm. of the typical form. Typical *A. linearis* has scarcely visible lateral veins, while in the Tasmanian plants attributed to *A. linearis* the lateral veins are almost reticulate and the texture apparently thicker. I concur in Mr. Rodway's opinion to merge such a form as this in *A. mucronata* Willd., and suggest that *A. linearis* Sims be not adopted as a Tasmanian plant without further evidence.

d. ACACIA PYCNANTHA Benth.

Bentham records this species only from South Australia and Victoria. The New South Wales specimens I have seen have not been entirely satisfactory, and, being an important species for tan-bark, it has been tested from end to end of New South Wales, and it is growing in innumerable places where it is not spontaneous. It is therefore desirable to give authentic records for New South Wales.

Tree of twelve feet, on slopes at head of Cuttagee Lake and Creek, near Bermagui, South Coast.

In flower August, and fruit December 1915 (W. Dunn).

I asked Mr. Dunn, who is a shrewd observer, if there was any possibility of the plant having been artificially sown and he replies emphatically in the negative.

e. ACACIA LINEATA A. Cunn.

This was originally described in G. Don's "Gen. Hist. of Dichlamydeous Plants," II, 403, 1832. The locality for the type was not stated in that work (it can of course be laboriously traced in Allan Cunningham's Mss.), but Bentham quoted "Liverpool Plains, Wellington Valley etc."

It is somewhat variable and occurs from the Mallee country of Victoria through the mid-west of New South Wales to southern Queensland. It is not noted from

Queensland by Bentham, but Bailey records it from Eumundi, and I add Inglewood to it.

The South Australian localities of Bentham are those of *A. imbricata* F.v.M., a form which, if conspecific with *A. lineata*, which is open to doubt, is furthest remote from that species of all the forms. See below, p. 499.

With the help of Miss Flockton and Mr. W. F. Blakely (my assistants) I have examined a good deal of material of *A. lineata*, and the following notes will show the amount of variation observed in the species.

I have divided the material into groups of specimens (provisional groups for the purpose of this paper, and more or less empirical). These groups run into each other a good deal, but there is a sequence in them, beginning at Group 1 until we come to Group 5, which contains the forms nearest to *A. imbricata* F.v.M.

Pictorial illustration is necessary to describe them fully, but I trust that the following notes will be helpful.

Group 1. Phyllodes hairy, nearly all with a gland at base on the *inner* side about a quarter way up. Mid-nerve nearly central, and the tip straight or nearly so, not hooked. Peduncle sparingly hairy.

Flowers in heads on peduncles (hairy) shorter than the phyllodes. Calyx irregularly lobed, hairy. Petals free, glabrous. Pistil hoary or smooth.

Parkes (J. L. Boorman).

Group 2. Phyllode hairy and hooked at tip. Mid-vein nearer to the lower edge, gland towards base.

Flowers on glabrous peduncles, exceeding the phyllodes.

Peak Hill (J. L. Boorman), Tomingley to Narromine (J.H.M.) With these may be associated:—*Not* exceeding the phyllodes, phyllodes hairy, gland; four feet high, spreading habit. Bygo Run viâ Wagga Wagga (J. R. Taylor).

Group 3. Phyllodes 1-nerved, covered in long weak hairs, "an oblique callous mucrone at the apex," stipules minute, very deciduous.

Flower heads on glabrous peduncles not so long as the phyllodes, large sheath-like bracts at the base of the peduncle. Calyx narrow, irregular, free nearly to the base, hairy. Petals free, glabrous, five-merous. Pistil hoary or rather papillose.

Liverpool Plains (?Allan Cunningham); Near Dubbo (E. Betche); Gulgong (F. E. Haviland).

Group 4. Phyllodes clammy, one-nerved, a few scattered hairs, minute deciduous stipules; "oblique-callous mucrone at the apex," gland near base.

Flowers in heads, on glabrous peduncles exceeding the phyllodes, and with a large sheath-like bract at the base. Flowers small and frail. Calyx irregularly lobed, fringed with hair. Petals five-merous, glabrous. Pistil hoary.

Bogan Gate and Wyalong (J. L. Boorman), Wyalong and Temora (Rev. J. W. Dwyer). There are two different looking forms from Temora, one compact in habit and more pubescent than usual (? *A. dasyphylla* A. Cunn.) the other of a more open habit, the phyllodes further apart.

I may remark that Group 3 is closely related to Group 4, but the phyllodes of Group 3 are thinner in texture, and have a marked nerve. In Group 4 the phyllodes are thicker, with thick margins, and the nerve although present is not distinct, but is lost in the thickness of the margin.

I am of opinion that both No. 3 and No. 4 are very near the type of *A. lineata*. It may be desirable to bring under notice the original description of *A. lineata*, which is as follows:—

A. lineata (Cunningh. Mss.), stipulas wanting or deciduous; *phyllodia* linear, ending in an oblique, callous mucrone

at the apex, glandless, one-nerved, the nerve parallel with the superior margin and contiguous with it; *phyllodia as well as the branches hairy;* heads of flowers usually twin; *peduncles* filiform, longer than the phyllodia; *phyllodia* half an inch long. (Don, "Gen. Hist. Dichlamydeous Plants," II, 403, 1832).

I am further of opinion that *A. dasyphylla* A. Cunn., which is a more pubescent form of *A. lineata*, comes under Group 3 or 4.

Group 5 (a glabrous form). Phyllodes glabrous except a few hairs at the base, one-nerved, *one* thick nerve-like edge, point oblique, but not pronounced, gland near base.

Flowers in heads, on glabrous peduncles not exceeding the phyllodes. Calyx narrow, irregular, hairy, free nearly to the base. Petals free, glabrous, five-merous. Pistil hoary.

[This includes *A. runciformis* A. Cunn., in part.]

Specimens falling in Group 5 come from Mallee country of Victoria (St. Eloy d'Alton, C. Walter); Goonoo (Mudgee to Dubbo) (J. L. Boorman); also Dubbo (J. L. Boorman); Gunnedah (J. L. Boorman); W. L. Waterhouse, Ticketty Well, between the Gwydir and McIntyre Rivers (E. H. F. Swain); Inglewood, Queensland (J. L. Boorman).

An affinity of *A. lineata* to *A. aspera* Lindl. is worthy of note. They are in two sub-groups in Bentham's classification, viz.:—subseries Armatæ and Brevifoliæ respectively of the Uninerves, but the latter species may have phyllodes so small, and of such a shape that they may readily be confused with the latter.

f. Acacia imbricata F.v.M.

I have examined a specimen of the type (in fruit) from Tumby Bay, Spencer's Gulf, S.A., through the kindness of Professor Ewart, and have a flowering specimen (cultivated) from another source.

Following is a translation of the original description :—
Glabrous, branches crowded, with acute angles, stipules obsolete, phyllodes small, crowded, sessile oblong or cuneate-linear, with one nerve, veinless, obtuse, having a gland at the apex, obliquely cuspidate apiculate, peduncles solitary in the axils, exceeding the phyllodes; pods broadly linear, papery, somewhat sessile, slightly compressed, full or many seeded, the suture straight, seeds round-ovate, slightly compressed, shining, blackish, twice as long as the acuminate cymbiform aril.

In scrub near Tumbey (Tumby) Bay on the shore of Spencer's Gulf. (C. Wilhelmi).

A dense shrub three to four feet high. Phyllodes two to six lines long, half to one line broad. Peduncles thin, often half an inch long. Pod two to three lines broad. Seeds about one and a half lines long, distinctly areolate.

The species certainly belongs to the Uninerves, and has affinity with *A. lineata*. According to the illustrious Bentham, *l.c.*, it is allied to *A. conferta* (series Brunoideæ) which only flourishes in eastern Australia, but it differs from it. It is of much taller habit, the pubescent branches are not distinctly angled, the phyllodes are acute without a terminal gland, with scarcely any nerve, and with a sufficiently distinct margin, pod very much compressed, crowded, much broader, hoary, few seeded, the sutures flexuose, the larger seeds less shining and more compressed, not distinctly areolate and perhaps in the flowers also. ("Fragm." I, 5, 1858).

A. imbricata is more willowy, less rigid than *A. lineata*.

It comes next in the series (of the groups of *A. lineata*) to Group 5. Its points may be briefly set out.

Phyllode glabrous, one-nerved with a gland on the upper portion of the phyllode, at the apex between the nerve and the margin. This is appressed to a small "oblique callous mucrone" at the apex between the nerve and the lower margin. The apex, with this gland and callous mucrone, appears thickened and bifid. This is very unusual and may be unique.

The phyllodes are imbricate to the extent that I have never seen in *A. lineata*; indeed the appearance is very different.

Flowers in heads, on glabrous peduncles exceeding the phyllodes. Calyx narrow-linear, hairy. Petals free, glabrous, five-merous. Pistil smooth and shiny.

The pod is straight and smooth with a short funicle terminating in not a large aril. The pod of *A. lineata* is much twisted, is covered with glandular hairs and has a larger more folded aril.

It seems to me that a strong case has been made out for the recognition of *A. imbricata* F.v.M. as a species distinct from *A. lineata*.

g. Acacia Bynoeana Benth.

This species is in the "Flora Australiensis" only recorded from the type locality (North West Australia), and also from the Gulf of Carpentaria.

Some years ago, I received from the late Mr. C. Walter of Melbourne, an undated specimen collected by Mr. St. Eloy D'Alton at Nhill, in the Mallee country of Victoria. He (Mr. Walter) had marked it "*calamifolia* var. *Wilhelmsiana* or *nematophylla*." This specimen is *A. Bynoeana*, and there is a reference to an "*A. Wilhelmsiana*" from the Murray Scrub by Bentham under *A. Bynoeana*.

I received the same species from South Australia from Mr. Walter Gill in January and December 1909. It came from the same general district as Mr. D'Alton's specimen. The following note was furnished by Mr. Gill:—

"It is very common in the Parilla Forest, and all about the Mallee scrub, over a wide extent of the Pinnaroo district, which lies between Tailem Bend (on the Melbourne-Adelaide line) on the west, and the Victorian border on the east."

It is also found in New South Wales. There is a specimen in this Herbarium from the Lachlan River, dated September 1882, by an unknown collector. It was also received from P. E. Lewis of Shuttleton near Cobar in January 1908, and from Archdeacon F. E. Haviland from the same locality in September 1911. There is a note by the latter in "Proc. Linn. Soc. N.S.W." XXXVIII, 645, (1913) under the name *A. lineata* A. Cunn., which is my fault.

Both Mr. Gill's specimens (No. 1) and Archdeacon Haviland's (No. 2), are quite satisfactory, but as the species is so little known, I trust that the following notes on them will be helpful:—

No. 1—Phyllodes narrow, semi-terete or thick, two distinct parallel nerves, hooked or curved apex, gland near base, very resinous, stipules minute.

Flower-heads on a peduncle with golden hairs and sheathing bracts. Calyx irregularly lobed, thick, hairy. Petals with a few hairs. Pistil hoary, *i.e.*, not very pubescent.

No. 2—Phyllode, sometimes one, usually two-nerved, curved or hooked very much, resinous, a few hairs on the edges and nerves, chiefly on the lower half of the phyllode. Phyllode articulate between two minute stipules.

Flowers in heads, hairy, the peduncles short, covered in a golden pubescence and subtended by a large bract. The peduncle does not exceed the phyllode. Calyx turbinate, hairy, *i.e.*, similar to the Parilla specimens, but the calyx more expanded. Petals hairy on the upper half. Pistil pubescent.

h. ACACIA IXIOPHYLLA Benth.

(Syn. *A. glutinosa* F.v.M. and *A. fuliginea* R. T. Baker).

i. A. MONTANA Benth.

I desire to invite attention to the very great confusion which has arisen in regard to the above species. That

confusion, which Mr. Baker tried in part to clear up by the proposal of a new species *(fuliginea)*, was acquiesced in by me, and much material was distributed from this herbarium under that name, but I will show that it is a synonym of *A. ixiophylla.* The confusion of *A. ixiophylla* and *A. montana* is brought under notice for the first time.

To clear the ground, I give translations of the original descriptions of *A. ixiophylla*, *glutinosa* and *montana.*

(A) *Acacia ixiophylla* Benth., Lond. Journ. of Bot., I, 364 (1842).

Very branched, glabrous or minutely pubescent, viscid, phyllodes narrow oblong-lanceolate, subfalcate, obtuse with an oblique apex and minutely mucronulate or glandular, thinly multinerved, narrowed at the base, peduncles downy, solitary or very shortly racemose, capitula under twenty flowers in the head.

Phyllodia under an inch in length, scarcely two lines broad, subcoriaceous and much thinner than *A. sclerophylla.* Most of the racemes two to three headed. North of Liverpool Plains, New South Wales. Cunningham (Allan).

(B) *Acacia glutinosa* F.v.M., in Fragm. IV, 6.

[N.B. the italics are those of the original.]

A shrub somewhat glabrous and *viscid*, the branchlets at first angular. Stipules obsolete, *phyllodes oblong-linear, gradually narrowed towards the base with many fine veins which are uniform and immersed (immerse)*, obtuse, minutely apiculate, straight or slightly curved, the two finely-downy peduncles about as long or a little longer than the many flowered capitula. The stipes of the bracteoles hair-like and the lamina sub-cordate or rhombic. Sepals linear, almost free, more than half as large as the corolla, *pods somewhat papery curled and flexuose, rather short, viscid,* broadly linear, with two valves continued within, seeds ovate, dark black, shining, arranged longitudinally and marked on either side with a large oblong faint areole, with a dark sub-lateral cymbiform strophiole about a third as long as the seed. In New Holland, South West Australia, (Maxwell).

A shrub many feet high. Phyllodes thinly coriaceous, 1 – 2″ long, $1\frac{1}{2}$ - $2\frac{1}{2}$‴ broad, somewhat sessile. The common peduncle very short or none, individual peduncles 2 – 3‴ long. Bracteoles somewhat glabrous, corolla 5 fid, and shorter. Pods glabrous, at the most 1 – $1\frac{1}{2}$″ long, 1 – 2‴ broad, compressed, very undulate, brownish. Seeds about $1\frac{1}{2}$‴ long. I have found no species in our large collection of Eastern Australian Acacias which I could consider to be the same. I much doubt, however, that it is that species concerning which the illustrious Bentham in (Linnæa XXVI, p. 625) notes a likeness to *A. ixiophylla*. (Fragm., IV, 6.)

(C) *A. fuliginea* R. T. Baker is described in English in Proc. Linn. Soc. N. S. Wales, XXXI, 712 (1906), and he gives figures of *A. fuliginea* and of what he deems to be *A. ixiophylla*.

At page 507 I will consider, *seriatim*, all the points to which Mr. Baker draws attention (at p. 713) in contrasting *A. fuliginea* and *A. ixiophylla*.

(D) *Acacia montana* Benth. in Lond. Journ. of Bot., I, 360 (1842).

Very viscid, branchlets subangular and with pubescent peduncles, phyllodes oblong or oblong-lanceolate, very obtuse, scarcely with a callous apex, narrowed at the base, glabrous, two-nerved, peduncles short, brownish, very short, bracts at the base, capitula small, multiflowered.

Affinity to *A. exsudans (A. verniciflua* A. Cunn. var. *latifolia* Benth.)

Phyllodia more obtuse, shorter (1 – $1\frac{1}{2}$ inches), veins more obscure. Peduncles thinner than the bracts at the base. Capitula much smaller. Highlands near the Liverpool Plains, New South Wales, *Fraser*.

A. IXIOPHYLLA Benth. and A. MONTANA Benth.

Mueller figured *A. montana* in his "Iconography of Australian Acacias" but did not figure *A. ixiophylla*.

The most obvious points of *A. montana* Benth. are:—

1. Hairy pod.
2. Peduncles with few or scattered hairs.
3. Laminæ of bracteoles rhomboid or foliaceous.
4. Phyllodes with two main nerves.

Contrasting with *A. ixiophylla* Benth., we have in the latter:—

1. Smooth, narrower pods.
2. Peduncles with short, dense tomentum.
3. Laminæ of bracteoles capitate (like the head of a nail, *i.e.*, with not much lateral expansion).
4. Phyllodes with three or more nerves, anastomosing more than in *A. montana.*

Following are the specimens of *A. montana* in the National Herbarium of New South Wales:—

New South Wales.—Angledool (Miss Newcomen) near the Queensland border.

Brigalow scrubs on the Severn (Leichhardt). [This is near the Queensland border]. Liverpool Plains (without collector's name. Perhaps a fragment of the type).

Deepwater and Emmaville Hill (J. L. Boorman).

Mount Lindsay (at 4,500 feet), Nandewar Mountains (R. H. Cambage, No. 2400). Phyllodes up to $2\frac{1}{2}''$.

Warrumbungle Ranges (W. Forsyth). Phyllodes broader than the type and with slightly fimbriate margins.

Tamworth (Revd. H. M. R. Rupp), Moor Creek near Tamworth (W. M. Carne).

Merriwa (J.H.M. and J. L. Boorman).

Elsmore, ten miles east of Inverell (R. H. Cambage, No. 1772).

The above are northern New South Wales. Then we have a gap to the south, with the following one as an intermediate locality:—

Wirlong-Nymagee (R. H. Cambage, No. 141; in bud only).

"Growing in bunches four or five feet high," five miles east of Temora (R. H. Cambage, No. 615). Temora (Rev. J. W. Dwyer, Nos. 223, 224, 230). Some of the phyllodes of Father Dwyer's specimens are under one inch as are also some of the Victorian ones.

Victoria.—Grampians (A. J. Campbell). Pomonal (J. Staer). Dimboola (St. Eloy D'Alton and J. Staer).

South Australia.—Murray Bridge (J. H. M. phyllodes only).

Drummond's specimens.—I now come to Drummond's fifth collection No. 13, referred to under *A. ixiophylla* by Bentham in B. Fl. ii, 387. Indeed he describes the pods ("very flexuose, hispid or glabrous, two to three lines broad") and also the seeds. These pods (the hispid ones) and seeds are not distinguishable from those of *A. montana.* The pods are, however, not fully grown, and the seeds seem to be arranged obliquely. The phyllodes are viscid, and are more pubescent than those of typical *montana*, but I think the material available is fairly referable to that species. Certainly it is not *A. ixiophylla.*

My specimen is fairly well represented by the right hand figure of Mr. Baker's Plate LXVI of *A. ixiophylla.*

This determination would extend the range of *A. montana* in a westerly direction from St. Vincent's Gulf to Western Australia.

Following are the specimens of *A. ixiophylla* in the National Herbarium of New South Wales:—

Queensland.—Miles, Dalby district (Collector of F. M. Bailey) in flower and fruit. Phyllodes 1–2″ by 4 mm. Pod as figured for *A. fuliginea* by Mr. Baker. Condamine River

(Leichhardt); Six to eight feet of weak, pendulous growth, Inglewood (J. L. Boorman).

New South Wales.—Brigalow scrub beyond the Severn (Dr. Leichhardt); Warialda (W. A. W. de Beuzeville No. 8 of 24th October, 1913). Pod as figured for *A. fuliginea*. Most phyllodes a little broader than those of the preceding specimens. "Middle sized shrub," Yagobie, between Moree and Warialda (District Forester). Wee Waa (T. W. Taylor, No. 5).

The following from the Pilliga Scrub:—(*a*) Brigalow Creek, eight to ten miles from Cuttabri (Dr. H. I. Jensen, No. 44). (*b*) On red soils between Wongan and Baradine (Dr. H. I. Jensen No. 71). (*c*) Twelve to eighteen feet (?) common in the Pine Scrub (J. L. Boorman). (*d*) eight to ten feet, much branched, common throughout the scrub, always liable to a smut. Cuttabri (J. L. Boorman). (*e*) About ten feet. In sandy clay with Pine and Ironbark. Cuttabri (E. H. F. Swain, No. 46). (*f*) Ten feet, Goona Creek (W. A. W. de Beuzeville, No. 2).

The following are co-types of Mr. Baker's *A. fuliginea* and I cannot see in what respect they differ from *A. ixiophylla*. They simply continue the series of *ixiophylla* specimens. The position is that either *A. ixiophylla* or *A. fuliginea* cannot stand.

Bylong Ranges, also Camboon, seven miles north of Rylstone, October 1893 (R. T. Baker); also Goulburn River 1896, same collector.

A. IXIOPHYLLA Benth. and A. FULIGINEA R. T. Baker.

We now come to consideration of the points Mr. Baker advances (Proc. Linn. Soc. N.S.W., XXXI, 713) as differences between these two species.

1. *Flowers in the head.*—Of *A. ixiophylla* Bentham says (Lond. Journ. Bot.) "under 20 flowers." In B. Fl. ii, 337, he says, "15 to 20 or rarely more."

Mr. Baker says—(*a*) "It *(fuliginea)* has twice as many flowers in the head" as *A. ixiophylla*, and at p. 712, *A. fuliginea* has "about 40 flowers."

The material at my disposal has been very carefully examined with the following results: I have seen no head with as few as 20, but various numbers up to 35. On the evidence I should give the limits as 24 and 35. All in the following list have been hitherto regarded as *A. ixiophylla* (some have actually passed through the hands of Bentham, Mueller and F. M. Bailey). The co-types of *A. fuliginea* fall into the series quite naturally.

Bylong Ranges and Rylstone, co-types of *A. fuliginea* R. T. Baker, flowers in the head 35. All the rest are *A. ixiophylla.*

Brigalow Creek, Pilliga (Jensen), flowers in the head average 24; Wongan and Baradine (Jensen), flowers in the head between 30 – 35; Pilliga (J. L. Boorman), an average of 25 flowers in the head; Cuttabri, Pilliga (J. L. Boorman), an average of 30 flowers in the head; Pilliga Scrub (E. H. F. Swain), flowers in the head 30; Goona Creek (W. A. W. de Beuzeville), flowers in the head 30; Wee Waa (T. W. Taylor) flowers in the head not less than 35; Brigalow Scrub beyond the Severn (Dr. Leichhardt, seen by Bentham and Mueller), flowers from 30 to 35 in the head; Condamine River (Leichhardt, seen by Bentham and Mueller), flowers in the head 30; Inglewood (J. L. Boorman), flowers in the head 25; Miles (seen by F. M. Bailey), flowers in the head 35.

2. *Phyllodes.*—For the original description of them in Lond. Journ. Bot. I, 364, see above.

In B. Fl. ii, 387, Bentham adds a few modifications, the principal of which are, "$\frac{3}{4}$ to $1\frac{1}{2}$ or near 2 in. long, 2 to 3 or rarely 4 lines broad."

Mr. Baker *(loc. cit.)* says *(b)* "The phyllodes (of *A. ixiophylla* and *A. fuliginea*) have quite a different shape and are larger in size." Let us consider these points *seriatim*.

Shape.—The original shape is "narrow oblong lanceolate, sub-falcate, with an oblique apex."

Bentham later (B. Fl. ii, 387) does not alter this description in an important manner. Mr. Baker figures *A. ixiophylla* much longer and narrower than *A. fuliginea*.

After examining a long series I fail to find any difference between *A. ixiophylla* and *A. fuliginea* in respect of shape.

Size.—The original description for *A. ixiophylla* says "under an inch in length, scarcely two lines broad." In B. Fl. ii, 387, he alters it to $\frac{3}{4}$ to $1\frac{1}{2}$ or rarely nearly 2 in. long, 2 to 3 or rarely 4 lines broad.

Mr. Baker gives the size of *A. fuliginea* as "2 to 3 or even 4 cm. long, and varying up to 1 cm. wide." These figures are included in Bentham's as regards the length, and, as regards the width, Bentham's are $\frac{1}{6}$ to $\frac{1}{3}$ inch, and Mr. Baker's are "varying up to $\frac{2}{5}$ inch." I find phyllodes of *A. ixiophylla* agreeing with Bentham's dimensions for *A. ixiophylla* and with Mr. Baker's figure of *A. ixiophylla*, and with his description and figure of *A. fuliginea*.

Venation.—Bentham in the original says "thinly multinerved." In B. Fl. ii, 387, he amplifies this into "striate, with numerous fine but prominent nerves, anastomosing when the phyllodium is broad."

Mr. Baker says of his *A. fuliginea* "with several nerves and intermediate reticulations." These words are simply Bentham's in another form. In his figure, however, Mr. Baker figures *A. ixiophylla* with three or more nerves, and *A. fuliginea* with three to five. I fail to note any difference between them.

It is sometimes difficult to say how many nerves there are in *A. ixiophylla* as the texture of the phyllodes may be thickish and resinous, and it is difficult to distinguish between the nerves and the striæ. Mueller expresses the idea in the use of the word "immerse" when speaking of the veins of *A. glutinosa*. One sees long fissures but one cannot exactly state their character with a lens.

Gland.—Mr. Baker, in describing *A. fuliginea* speaks of "gland wanting," but that is a slip. There is in all *A. ixiophylla* material (whether attributed to *A. fuliginea* or not), a rather large gland, but it is near the base of the phyllode and not easy to see unless the phyllode is detached. The liability to pass it over is enhanced by the ruggedness of the surface of the phyllode owing to the glandular protuberances.

Indument.—There is variation in the species. Bentham expresses it as "glabrous or pubescent glutinous." This is worthy of emphasis. The name *fuliginea* is owing to the sootiness of the phyllodes, which can be observed in *A. ixiophylla* from widely separated localities.

Inflorescence.—(*c*) The inflorescence is referred to by Bentham, . . . "solitary, or very shortly racemose." . . . Most of the racemes 2–3 headed." In B. Fl. ii, 387, "Peduncles in pairs on short racemes of three or four."

Mr. Baker says of *A. fuliginea* (*d*) "The inflorescence is not in racemes," and again . . . "Solitary or in pairs on the end of the newly formed branchlets."

Careful examination of a long series of *A. ixiophylla* (including specimens labelled *A. fuliginea* by Mr. Baker) shows that the flower-heads are in pairs on short racemes. In one case (viz. Miles, Queensland, F. M. Bailey), the flower-heads are solitary, in pairs or threes, on short racemes. It will be seen that they all come under *A. ixiophylla* as described by Bentham.

Pods.—Bentham in describing *A. ixiophylla* does not describe the pods. In his later and amplified description (B. Fl. ii, 387) he adds a description of Western Australian pods (Drummond's in fact, which do not belong to this species, and which I attribute to *A. montana*).

Mr. Baker *(loc. cit.)* contrasting the pods of *A. fuliginea* with those as described by Bentham says:—

(*e*) "The pods are much longer and narrower."

I have already referred to specimens which are *A. ixiophylla,* have its narrow pod, and which in no way differ from the flowering and fruiting specimens attributed by Mr. Baker to his *A. fuliginea,* and credit is due to that gentleman for prominently drawing attention to the pod of *ixiophylla (fuliginea).*

A. glutinosa F.v.M. A translation of Mueller's original description has been already given. It is quite clear, and Professor Ewart has favoured me with a portion of the type. (Maxwell, Western Australia).

It will be seen that Bentham (B. Fl.ii, 387) has referred it to *A. ixiophylla,* qualifying it by "the western specimens," but, so far as I am aware, no specimens other than those from Western Australia have ever been referred to *A. glutinosa.*

I have also a specimen from Kellerberrin, West Australia (R. B. Leake). As these Western Australian specimens are but little known and seem to be conspecific, I will describe them in a few words:—

1. *Type.*—Phyllode finely veined, two nerved, sharp mucrone, glabrous.

Flowers about thirty-five in the head.

Bracteole slight, oblique-capitate, glandular or hoary on the top.

Calyx-lobes divided half way down or more, nerved, hairy at the top.

Petals free or united near the base, glabrous.

Pistil hoary at the top.

Pod much twisted (convolute), smooth, with transverse veins.

Seed placed longitudinally in the pod, with short funicle.

2. *Kellerberrin specimen.*—Phyllode entirely glabrous, with oblique sharp-pointed tip, two main nerves.

Flower-heads in pairs on a short peduncle about twenty-three in the head. A narrow bract at the base of each head of flowers. Each bracteole capitate or with a slight point, and having a few hairs. Flowers five merous.

Calyx cup-shaped, lobed, extremely thin and transparent, thickened at the tip, a few hairs at the apex, no central nerve.

Petals thickened at the top, with a central nerve, glabrous.

Pistil smooth, sometimes hoary at the top.

As regards the pods of *A. ixiophylla,* Bentham never saw them, but assuming that the Western Australian specimens are that species, he described the pod as "very flexuose, *hispid (A. montana* Benth., J.H.M.) or glabrous, *(A. glutinosa* F.v.M., J.H.M.) two lines broad." He is thus combining the pod of Drummond's fifth Coll. No. 13[1] which is *A. montana* and which is hispid (see Mr. Baker's figure of *A. ixiophylla),* and Maxwell's specimen of *A. glutinosa* which Mueller tells us has "Legumina glabra." (Fragm. IV, 7.)

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[1] Drummond's specimens were unaccompanied by localities as every botanist knows, and as regards Maxwell's, Mueller often labelled them "South West Australia" as in the present case, and often "West Australia." Maxwell collected chiefly in the King George's Sound and Stirling Range district and accompanied Drummond to the Stirling Range. See Proc. W.A. Nat. Hist. Soc., 1909.

As regards Drummond, some of his fifth collection undoubtedly came from the King George's Sound-Stirling Range district.

Allowing for some variation in plants separated from each other by the width of a continent, I think that the resemblance of *A. glutinosa* F.v.M. to *A. ixiophylla* Benth., is remarkably close, and concur in Bentham's proposal to combine them.

The range of *A. ixiophylla*, as we know it, affords a remarkable instance of geographical distribution. The species is a denizen of moderately dry localities, and we have it from central Queensland south to the Rylstone district in New South Wales. Then we have a gap until Western Australia is reached and I would invite the attention of botanists to the matter. It (and indeed *A. montana*, when not in fruit) are species which can readily be passed over for allied species.

I have a specimen from the Mallee, Wimmera River, Victoria, C. Walter, 10th March 1887, which that gentleman sent to me as *A. montana*. It is in pod, without seeds. I have little doubt that it is one of the localities destined to bridge the present *A. ixiophylla* gap.

EUCALYPTUS AUSTRALIANA, SP. NOV. ("NARROW-LEAVED PEPPERMINT") AND ITS ESSENTIAL OIL.

By R. T. BAKER F.L.S. and H. G. SMITH, F.C.S.

[*Read before the Royal Society of N. S. Wales, December 1, 1915.*]

Introduction.

When studying the Eucalypts of Tasmania for our paper on those of that Island,[1] Labillardière's species of *E. amygdalina* necessarily received much attention, as it was from that Island he obtained his material, which, of course, stands as the authenticated species. The name, however, has long since been also given to a tree on the mainland, and it was only when investigating the species for the above research, that differences were detected in the two trees, and these have since been followed up. In fact, the differences were so marked that even then we raised the continental form to varietal rank under the name of *Eucalyptus amygdalina* var. *australiana*, being loath to introduce another species name to the already long list of Eucalypts. We were prepared to let it stand at that, but the technology of this Eucalyptus has since come so much to the front in the commercial world, that we think it best in the interest of applied, as well as pure science, to give it specific rank, for which we propose the name *Eucalyptus australiana* for the mainland tree.

A systematic description is added so that the species upon which the research is made might be clearly understood. It is figured in "Research on the Eucalypts and Essential Oils," 1902, under "Messmate," *Eucalyptus amygdalina*, p. 168. The broad-leaved form is restricted to the Ovens district of Victoria.

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[1] Proc. Roy. Soc. Tasmania, 1912.

The differentiation of the species from that of Labillardière of Tasmania is justified, we think, on both botanical and chemical grounds, as mentioned by us in our paper on the Tasmanian Eucalypts.

The commercial world is no longer satisfied with common names to plants, but looks to the botanical name as definitely placing not only the tree but also the products obtained from it. Orders for our botanical products placed in Australia from Europe and America invariably now give the specific name of a species, and as there is a great commercial future before the oil of this tree, it is only right we think, that the opportunity should be taken to bring commerce into line with science.

Systematic Description.

It attains forest tree height, but more often is only a medium sized tree. The bark is persistent on the stem, and well out on the branches. It has what is known as "peppermint" bark, and quite characteristic, being of a compact, fibrous nature, but yet distinct from the ordinary "Stringybark." It more nearly approaches that of the "Boxes," but the fibres are straight, not checkered as obtains in that group of Eucalypts.

The "sucker" leaves are sessile, opposite, cordate-lanceolate, normal leaves narrow lanceolate to broadly lanceolate (Victoria), venation distinct, lateral veins mostly at an angle of about 40° with occasionally a few at a very acute angle and long spreading, intramarginal vein removed from the edge.

Peduncles axillary with a varying number of flowers. Calyx turbinate, short. Operculum obtuse, flattened. Stamens all fertile, anthers kidney-shaped. Fruit pilular to turbinate, rather small comparatively, from two to three lines in diameter, with red rim, and a thin contracted edge, valves not exserted.

It differs from *E. amygdalina* Labill. in the shape of the fruit, lacking the slightly domed rim of that species, and is less inclined to top-shape, whilst the leaves are longer, and the lateral veins less acute than in that species. Labillardière's species has a bluish tint after drying, a character not occurring in this species. Systematically, it might be placed next to *E. piperita*.

Timber.—The timber is pale but darkening to a light chocolate on exposure, is very fissile, and subject to gum veins. Among Eucalypts it might be ranked as a second class timber. It is light in weight, and suitable for general building purposes. Opinions vary as to its durability in the ground.

Distribution.—It has an extensive geographical distribution on the ranges of Victoria and New South Wales, and probably it extends into Queensland, the localities being too numerous to publish here.

Essential Oil.

The production of an excellent pharmaceutical Eucalyptus oil from this species depends largely upon a fact which was first demonstrated by us in 1902, and published in the "Research on the Eucalypts," p. 170. We were able, at that time, to show that by fractional separation at stated times during the primary distillation, an oil richer in cineol could be obtained, particularly if the portion which came over during the first hour was separated. The cineol was thus more easily distilled than the alcoholic bodies and other oil constituents in the leaf. By taking advantage of this peculiarity, and working the trees growing at Nerrigundah, Yourie, and neighbouring districts of New South Wales in the same way, it has been possible to produce a product of a fairly constant character, high in cineol content, and answering to the requirements demanded for a first class pharmaceutical Eucalyptus oil. The results

have been so satisfactory that the species is, at the above localities, now worked in this way, the first hour oil being sold for pharmaceutical purposes, the remainder being employed for mineral separation and for other industrial uses. The chemical results obtained with this oil, separated as nearly as possible one hour after commencing to distil, are remarkably constant, so much so that it is not difficult to decide whether the distiller has extended the time of separation beyond the hour.

The remarkably high yield of oil given by this species enables this mode of working to be profitably undertaken, and the amount obtained during the first hour is almost as great as that from many other cineol producing species when these are distilled right out. The second hour oil thus becomes practically a subsidiary product. Little advantage appears to be derived from distilling the leaves for a longer period than two hours, as the amount of oil thus obtained is but small. The first hour oil, when properly prepared, is almost water-white, which fact appears to be due to the presence of the phenol, Tasmanol,—common to this class,—containing a methoxyl group, a constitution which does not permit the formation of a quinone, as is the case with the oils of the other large class of cineol producing Eucalypts. The amount of volatile aldehydes in the crude oil is but small, so that altogether no rectification of the first hour oil is needed before placing it on the market. This species of Eucalyptus, considered as a pharmaceutical oil producing tree, thus becomes of considerable importance from an industrial point of view, particularly as the country where it grows plentifully is usually of little value for agricultural purposes. This area might profitably be set apart for the preservation of this species of Eucalyptus, and for the establishment of a permanent industry in the production of this particular Eucalyptus oil.

Our attention was first directed to an increased amount of cineol in the oil of this species in trees growing in the Southern Coast District of New South Wales, by Mr. W. T. Farrell, early in 1913. He had collected his specimens at Nerrigundah, in which locality the "Narrow-leaved Peppermint" or "Black Peppermint" occurs somewhat abundantly. Arrangements were soon made to distil the oil in commercial quantities, and for some time analyses were made at the Technological Museum on the oil collected each month. In November of that year the Museum Collector sent material from Yourie and Tanto, in the Cobargo district. This was distilled at the Museum, and the results of the analysis of the oil are given in this paper. Later, one of us paid a visit to this portion of New South Wales, and by the courtesy of the District Forester at Moruya, Mr. Clulee, and of his assistant, Mr. Harrison, who drove his car, was enabled to make extensive observations, over a considerable area of country, concerning this Eucalyptus. Since that time, numerous analyses of the oil have been made for distillers, who have prepared the oil for market, and quite a minor industry has been established in the production of this particular Eucalyptus oil.

The determinations of rotation so far made has mostly shown the first hour oil to be slightly dextro-rotatory, although if the distillation be continued longer, the resulting oil may be slightly lævo-rotatory. This result appears to be due to the phellandrene not distilling so readily as does the cineol. Further improvements in this method of first distillation, will result in the production of a pharmaceutical oil from this species growing in other localities, and already experiments, in a small way, have succeeded in producing an oil containing as much as 70% of cineol, although the whole oil would not contain more than about 45% of that constituent. The separation of the phellandrene from the cineol by direct distillation cannot be so satisfactorily

accomplished, as the boiling points of the two substances are too closely in agreement, so that it must be to the modification of the process of steam distillation that improved results may be looked for from this species, in districts where the oil contains more phellandrene and consequently less cineol than does that from trees growing in the Nerrigundah and Yourie districts.

It is perhaps due to climatic influences, in addition to those of altitude and soil conditions, that the increased cineol content in the oil of the Nerrigundah trees has become sufficiently distinct to be noticeable as a general rule. In our work on the Eucalypts, p. 275, we drew attention to some remarkable features shown by the oil of this species, particularly that of solubility in 70% alcohol, a result which placed the species in that class yielding Eucalyptus oils richest in cineol, thus practically predicting the present results. This high solubility of the phellandrene bearing oil of this Eucalyptus is evidently largely due to the presence of an, at present, undetermined alcohol. This is suggested from the increased saponification numbers of the acetylated higher boiling fractions, and is also shown from the results with the Nerrigundah second hour oil. For comparison with this, the results of the second fraction of the oil of this species, distilled for us by Mr. Douglas, at Moss Vale in November, 1915, are given. This fraction boiled between 193° and 210° C.

Saponification number for esters in second hour oil = 11·4
,, ,, for same fraction acetylated = 95·1
,, ,, for esters, second fraction, Moss Vale oil = 11·1
,, ,, for same fraction acetylated = 94·4

The changes in constituents which can thus be observed seem to be between the cineol and the phellandrene. Further research may decide in what manner this has been brought about.

Yield of Oil.

The yield of oil from the Yourie-Tanto material agrees with that of this species from other localities, and our sample, distilled at the Museum, gave 4·4% for leaves with terminal branchlets, collected in the month of November, when the temperature is usually high. The material, which had dried somewhat, was weighed into the still and the amount of oil correctly determined. These figures may perhaps be considered as the maximum yield. The greatest quantity of oil from most species of Eucalyptus is obtained during the summer months, and the least yield during the winter. From a series of results obtained by Mr. E. McGrath of Yourie, during the months of June, July, August, September and October, these differences are strongly brought out. Mr. McGrath uses a pair of tanks coupled together and worked at the same time. These tanks are the usual 400 gallon square iron tanks fitted in the simple manner customary with the majority of Eucalyptus oil distillers in New South Wales. During the month of June the average weight of oil he obtained from the two tanks was, first hour oil 28 ℔s., second hour 12 ℔s., or an average per tank for each distillation of 20 ℔s. During July the average yield was, first hour 37 ℔s., second hour 11 ℔s, or an average yield per tank per distillation of 24 ℔s. During August the average yield was, first hour 39 ℔s., second hour 12 ℔s., or a yield of 25½ pounds per tank per distillation. During September the average yield was, first hour 42 ℔s., and second hour 12 ℔s., or 27 ℔s. per tank per distillation. For twenty-two days in October the average yield was 41 ℔s. for first hour, and 11 ℔s for second hour, or an average per tank per distillation of 26½ ℔s.

The actual weight of green leaves with terminal branchlets packed into the tanks was not taken, but if this weight be considered as 800 ℔s. per tank, which as an average

would probably be nearly correct, then for June an average yield of 2·5% was obtained; for July 3%; for August 3·2%; for September 3·4%; and for a part of October 3·3%.

We have been informed that as much as 90 lbs. of oil have been obtained from two tanks at one distillation with this species, 50 lbs. for the first hour, and 40 lbs. for second hour, but we have no other data by which to confirm this statement. Of course, if the leaves were more closely packed in the tank a greater amount of oil would necessarily be obtained from the distillation, although the amount of second hour oil seems out of proportion to that of the first hour.

Analysis of the Oil.

The crude oil of the Yourie and Tanto material, distilled at the Technological Museum, was of a very light lemon tint, had quite a pleasant odour, the volatile aldehydes not being at all pronounced. The oil contained a large amount of cineol. The reaction for phellandrene was not distinctive at this time of the year, although indications for the presence of that terpene were obtained with the first fraction.

The crude oil, which had been distilled right out, had a specific gravity at 15° C. of 0·9157; rotation $a_D = +2·8°$; refractive index at 20° C. = 1·4644; and was soluble in 1·2 volumes of 70% alcohol. On fractionation only 2 cc. of acid water and some oil containing aldehydes came over below 172° C. (corrected). Between 172° and 193° C. 84% distilled. This fraction had specific gravity at 15° = 0·9119; rotation $a_D = +2·7°$; and refractive index = 1·4623. It was very rich in cineol. The second fraction only represented 5% of the total oil, and this distilled between 193° and 220°. It had specific gravity at 15° = 0.9165; rotation $a_D = +0·8°$; and refractive index = 1·4679. The third fraction was also 5%, distilling between 225° and 260°. This

had specific gravity 0·938; rotation $\alpha_D = + 0·6$; refractive index = 1·4861.

The cineol was determined by the resorcinol method in the first fraction, and calculated for the whole oil, the result showed the crude oil to contain 70% of that constituent. The higher fraction contained a little piperitone (the constituent of peppermint odour), a small amount of ester, and some free alcohol. The saponification number for the esters plus free acid in the crude oil by boiling was 8·9. A portion of the crude oil was acetylated in the usual manner, when the saponification number had risen to 51·3. This result indicates the presence of an alcohol in fair quantity, to which constituent the aromatic and somewhat characteristic odour of the oil is evidently largely due. The presence of this alcohol is more distinctly shown with the second and third hour oils, which were distilled and collected for us by Mr. Gough, of Yourie.

First Hour Oil.

As previously mentioned, the commercial distillation of this species has resolved itself into a fractional separation during the primary distillation of the oil from the leaf.

The first hour oil is practically water-white, as are all the rectified oils of this group; it is rich in cineol, of good odour, and is fairly constant in composition, as can be seen from the following tabulated results. The average specific gravity of the first hour oil taken by Mr. McGrath at his works for twenty-six distillations during the months of September and October was 0·919, the highest being 0·920, the lowest 0·917.

The following analyses were made at the Technological Museum on the first hour oil of this species. The dates of distillation, the distillers, and the various localities are given. Nerrigundah, Yourie, and Reedy Creek are all situated in the south-eastern portion of New South Wales, between the Moruya and Cobargo districts.

Locality and date.	Sp. gr. at 15°C.	Rotation α_D	Solubility in 70% alcohol.	Refractive Index at 20°C.	Cineol.
Nerrigundah Mr. Farrell 1/1913	0·9188	+1·7°	vols. 1·1	1·4614	over 70%
Do. 4/1913	0·9188	+0·3°	1·1	1·4621	do.
Do. 5/1913	0·9190	+0·0°	1·1	1·4622	do.
Do. 6/1913	0·9190	+1·3°	1·1	1·4633	75% phosphoric acid method.
Do. 7/1913	0·9200	+1·5°	1·05	1·4627	over 70%
Do. 8/1913	0·9193	+0·9°	1·1	1·4628	84% resorcinol method.
Yourie Mr. Farrell 8/1913	0·9186	+0·5°	1·05	1·4624	over 70%
Do Mr. McGrath 8/1913	0·9186	−0·5°	1·1	1·4620	69·5% phosphoric acid method.
Do. do. 9/1913	0·9195	+0·4°	1·1	1·4622	over 70%
Nerrigundah Mr. Davidge 8/1913	0·9198	+0·3°	1·1	1·4617	do.
Do. Mr. O'Toole 7/1913	0·9191	+1·3°	1·1	1·4633	73% phosphoric acid method.
Do. Mr. Davidge 4/1914	0·9193	+1·5°	1·15	1·4631	over 70%
Yourie Mr. McGrath 4/1914	0·9199	+0·1°	1·1	1·4622	do.
Do. Mr. Gough 8/1914 (sampled from 10 cases)	0·9202	−1·2°	1·15	1·4636	71% phosphoric acid method.
Do. do. 8/1914 one case.	0·9211	+1·4°	1·1	1·4628	74% do.
Nerrigundah Mr. Coleman 3/1914	0·9179	+1·6°	1·15	1·4632	over 70%
Do. Mr. Davidge 3/1914	0·9195	+1·4°	1·1	1·4631	do.
Reedy Creek Mr. Young 9/1915	0·9196	+1·2°	1·1	1·4625	81% resorcinol method. 77% by phosphoric acid method.

These samples of first hour oil did not readily give definite reactions for the presence of phellandrene, although the lævo-rotation of some of the samples, and the slight rotation to the right of the others, suggest the presence of that terpene. The alcohol for the solubilities was 70% by weight. The resorcinol determination of the cineol was taken in the fractionated oil in that portion distilling below 190° C. The results are altogether too high if taken with the commercial sample directly, as higher boiling constituents are absorbed by the resorcinol. Where the percentage amount of cineol is definitely stated the results were carefully determined. In those cases where the amount is stated as being over 70% the percentage is approximate only. The specific gravities were corrected for 15° C., the factor 0·00075 for each degree above that temperature being used.

Second Hour Oil.

This sample of the second hour oil was forwarded to us by Mr. C. Gough of Yourie, and was a portion of the second hour oil he had commercially distilled. It was but little coloured, and had quite an aromatic odour. It had specific gravity at 15° C. = 0·9291; rotation $a_D + 2·2°$; refractive index = 1·4720; and was soluble in 1·1 volumes 70% alcohol. On distillation, 64% came over between 172° and 193° (corrected). This fraction had specific gravity 0·9131 at 15°; rotation $a_D + 3·3°$; refractive index 1·4655, and contained 31% cineol by the phosphoric acid method, representing 20% cineol for the second hour oil. 25% came over as the second fraction, boiling between 193° and 227° C. This had specific gravity 0·9283; rotation $a_D - 0·2°$; and refractive index 1·4760.

The saponification number for the esters in the second hour oil was 11·4, while in the acetylated oil it was 95·1. This latter figure represents 33% of ester if calculated for a $C_{10}H_{17}OH$ alcohol.

Third Hour Oil.

This sample was also forwarded by Mr. Gough. It shows but slight chemical differences from the oil of the second hour, except that the alcohol is a little more pronounced. It had specific gravity at 15° = 0·9266; rotation $\alpha_D + 2{\cdot}6°$; refractive index = 1·4747, and was soluble in 1·1 volumes 70% alcohol. Addition of more alcohol determined the presence of paraffin in both the second and third hour oils. The saponification number for the ester plus that of the free acid was 9·7; while with the acetylated oil it was 116·03.

On distillation 55% came over below 193°, and 35% between 193° and 225°. 26% of cineol was found to be present in the first fraction. The specific gravity of the first fraction was 0·9145; and the refractive index =1·4669. The second fraction had specific gravity 0·9267; rotation $\alpha_D - 1{\cdot}4$; refractive index = 1·4770. The saponification number for the ester plus that of the free acid was 9.4. A portion of the second fraction of the third hour oil was acetylated, when the saponification number had increased to 124·5. This indicates an ester percentage of 43·6 if the alcohol has the $C_{10}H_{17}OH$ molecule.

The determination of this alcohol is reserved for a later communication.

ABSTRACT OF PROCEEDINGS

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

MAY 5th, 1915.

The Annual Meeting, being the three hundred and seventy-second General Monthly Meeting of the Society, was held at the Society's House, 5 Elizabeth Street, Sydney, at 8 p.m.

Mr. C. HEDLEY, President, in the Chair.

Thirty-six members and six visitors were present.

The minutes of the General Monthly Meeting of the 2nd December, 1914, were read and confirmed.

The certificates of three candidates for admission as ordinary members were read for the first time.

Professor R. D. WATT and Mr. J. E. CARNE were appointed Scrutineers, and Mr. H. G. SMITH deputed to preside at the Ballot Box.

The following gentlemen were duly elected Honorary Members of the Society:—

Sir J. J. THOMSON, O.M., D.Sc., F.R.S., Nobel Laureate, Cavendish Professor of Experimental Physics in the University of Cambridge, and ANDREW GIBB MAITLAND, F.G.S., Government Geologist of Western Australia.

The President announced that on account of the War, it had been decided not to hold the Annual Dinner this year.

It was also announced that the following members had either gone or were preparing to go to the front:—

Dr. H J. W. BRENNAND, Dr. J. A. DICK, Dr. THOMAS FIASCHI, Mr. C. F. LASERON, Sir ALEXANDER MACCORMICK, Mr. A. M. MCINTOSH, Dr. JOHN S. PURDY, and Lieutenant-Colonel A. J. ONSLOW THOMPSON (killed in action).

The recent death of Mr. E. DU FAUR was referred to, as well as that of Lieutenant-Colonel ONSLOW THOMPSON, and it was resolved that letters of sympathy be written to the relatives of the deceased members.

On the motion of Professor POLLOCK it was unanimously decided that the special thanks of the Society be conveyed to Dr. QUAIFE for his handsome donation of a valuable lantern, automatic lamp, and projecting microscope.

The President tendered the congratulations of the Society to Professor DAVID and to Mr. J. H. MAIDEN, who had been awarded the Wollaston Medal by the Geological Society of London, and the Linnean Medal by the Linnean Society of London, respectively, and mentioned that these gentlemen had thereby become the first Australian recipients of the respective medals.

The receipt, during the recess, of 509 parts, 14 volumes, 35 reports, 3 maps, 2 catalogues and 1 calendar was reported.

The President congratulated Mr. E. C. ANDREWS on behalf of the Society, on his having been awarded the David Syme Prize.

It was announced that a series of Popular Science Lectures would be delivered.

The Annual Financial Statement for the year ended 31st March, 1915, was submitted to members, and, on the motion of the Honorary Treasurer, Dr. H. G. CHAPMAN, seconded by Mr. SUSSMILCH, was unanimously adopted:—

GENERAL ACCOUNT.

RECEIPTS.		£ s. d.	£ s. d.
To Subscriptions		545 13 0	
,, Rents—			
Offices	305 14 0		
Hall and Library	241 16 6		
		547 10 6	
,, Sundry Receipts...		10 11 3	
			1103 14 9
,, Government Subsidy for 1913 and 1914 ...			799 19 10
,, Clarke Memorial Fund—			
Advances for the year...			270 0 0
			£2173 14 7

PAYMENTS.	£ s. d.	£ s. d.
By Balance brought forward 1st April, 1914—		
Unpresented cheques	21 6 0	
Less :—Credit Balance at Union Bank ...	9 8 0	
		11 18 0
,, Salaries and Wages—		
Office Salaries and Accountancy Fees ...	155 16 8	
Assistant Librarian...	156 6 3	
Caretaker	106 10 0	
		418 12 11
,, Printing, Stationery, Advertising, Stamps etc.		
Stamps and Telegrams	40 0 0	
Office Sundries, Stationery, &c.	15 13 4	
Advertising	12 10 0	
		68 3 4
,, Rates, Taxes and Services—		
Electric Light	19 12 0	
Gas	6 1 8	
Insurance	20 3 9	
Rates	85 10 0	
Telephone	6 17 8	
		138 5 1
,, Printing and Publishing Society's Volume—		
Printing, &c.		191 0 0
,, Library—		
Books and Periodicals	33 18 6	
Bookbinding...	72 18 7	
		106 17 1
,, Sundry Expenses—		
Repairs	13 5 9	
Lantern Operator	10 2 6	
Sundries	38 11 11	
		62 0 2
Carried forward		996 16 7

PAYMENTS—*continued.*	£	s.	d.	£	s.	d.
Brought forward				996	16	7
,, Fixtures & Electric Light Fittings in Library				210	17	6
,, Interest on Mortgage	70	6	8			
Clarke Memorial Fund... ...	6	3	4			
				76	10	0
,, Australasian Association for the Advancement of Science—On account of repayment of Loan				200	0	0
,, Clarke Memorial Fund— Refund of Loan				620	0	0
,, Balance—						
Credit Balance, Union Bank of Australia, Ltd.	67	5	0			
On hand	2	5	6			
				69	10	6
				£2173	14	7

Compiled from the books and accounts of the Royal Society of New South Wales and certified to be in accordance therewith.

(Signed) H. G. CHAPMAN, M.D., *Honorary Treasurer.*

W. PERCIVAL MINELL, F.C.P.A.

SYDNEY, 13TH APRIL, 1915. *Auditor.*

BUILDING AND INVESTMENT FUND.

RECEIPTS.	£	s.	d.
To Loan on Mortgage from the A.A.A. Science— Balance as at 31st March, 1914	2500	0	0
,, General Fund— Amount received to date...	70	6	8
	£2570	6	8

PAYMENTS.	£	s.	d.
By A.A.A. Science— Amount repaid during the year...	200	0	0
,, Interest Account— Amount paid to A.A.A. Science...	70	6	8
,, Balance owing at this date	2300	0	0
	£2570	6	8

CLARKE MEMORIAL FUND.

BALANCE SHEET, 31ST MARCH, 1915.

LIABILITIES.

	£ s. d.	£ s. d.	£ s. d.
Accumulation Fund—			
Amount at 31st March, 1914 ...		574 8 2	

	£ s. d.	£ s. d.	£ s. d.
Brought forward		574 8 2	
Additions during the year—			
Interest Savings Bank ...	3 2 5		
„ Government Savings Bank	1 15 1		
„ Commonwealth Savings Bank	0 7 6		
„ General Fund ...	6 3 4		
		11 8 4	
			585 16 6
			£585 16 6

ASSETS.

	£ s. d.	£ s. d.
Royal Society General Fund		50 0 0
Cash Deposited in Savings Bank of N. S. W.	197 8 5	
„ Government Savings Bank	187 17 3	
„ Commonwealth „ „	150 10 10	
		535 16 6
		£585 16 6

STATEMENT OF RECEIPTS AND PAYMENTS, 31ST MARCH, 1915.

RECEIPTS.

	£ s. d.	£ s. d
To Balance at 31st March, 1914—		
Savings Bank of N.S.W.	164 6 0	
Government Savings Bank	5 2 2	
Commonwealth Savings Bank	5 0 0	
„ Interest to date (Six Months)—		174 8 2
Savings Bank of N.S.W.	3 2 5	
Government Savings Bank	1 15 1	
Commonwealth Savings Bank	0 7 6	
General Fund on Advances	6 3 4	
„ General Fund—		11 8 4
Amounts refunded to date...		620 0 0
		£805 16 6

PAYMENTS.

	£ s. d.	£ s. d
By General Fund—		
Advances to date		270 0 0
„ Balance at this date—		
Savings Bank of N.S.W.	197 8 5	
Government Savings Bank	187 17 3	
Commonwealth Savings Bank	150 10 10	
		535 16 6
		£805 16 6

A report on the state of the Society's property and the annual report of the Council were read as follows:—

Annual Report of the Council for the Year 1914-15.

(1st May to 28th April).

The Council regrets to report that we have lost by death six ordinary members. Ten members have resigned. On the other hand, twelve ordinary and two Honorary members have been elected during the year.

To day (28th April, 1915) the roll of members stands at 313.

During the Society's year there have been nine occasions when members have assembled as a body, namely,—eight monthly meetings and the Annual Dinner which took place at Farmer's Restaurant on the 30th April, 1914, when we were honoured by the company of the Hon. W. A. Holman, M.L.A., Premier and Colonial Treasurer, and the Presidents of several Societies.

The Council held ten meetings.

A special meeting was held on the 21st May, 1914, in commemoration of the Tercentenary of the publication of the *Mirifici Logarithmorum Canonis Descriptio*, when Professor H. S. Carslaw, Sc.D., delivered an address on "Napier and the Discovery of Logarithms."

Three Popular Science Lectures were given, namely:—

June 18—"*The Ore Deposits of Australia and their Origin*," by C. A. Sussmilch, F.G.S.

July 16—"*Comets*," by Professor Cooke, M.A., F.R.A.S.

October 15—"*The Milk Supply of a Great City*," by Professor Chapman, M.D.

Twenty-nine papers were read at the Monthly Meetings and these, with a good number of exhibits, afforded much instruction and interest to members of the Society.

On the motion of Mr. Hooper, seconded by Mr. Carne, Mr. W. P. Minell was elected Auditor for the current year.

The President, Mr. Charles Hedley, then delivered his Presidential Address.

On the motion of Mr. Sussmilch seconded by Mr. A. G. Hamilton, a hearty vote of thanks was accorded to the retiring President for his valuable address.

Mr. Hedley briefly acknowledged the compliment.

There being no other nominations, the President declared the following gentlemen to be Officers and Council for the coming year:—

President:

R. GREIG-SMITH, D.SC.

Vice-Presidents:

F. H. QUAIFE, M.A., M.D.	HENRY G. SMITH, F.C.S.
J. H. MAIDEN, F.L.S.	C. HEDLEY, F.L.S.

Hon. Treasurer:

H. G. CHAPMAN, M.D.

Hon. Secretaries:

R. H. CAMBAGE, L.S., F.L.S.	Prof. POLLOCK, D.SC.

Members of Council:

D. CARMENT, F.I.A., F.F.A.	J. NANGLE, F.R.A.S.
J. B. CLELAND, M.D., CH.M.	Prof. R. ROBINSON, D.SC.
Prof. T. W. E. DAVID, C.M.G., B.A., D.SC., F.R.S.	C. A. SUSSMILCH, F.G.S.
W. S. DUN.	H. D. WALSH, B.A.I., M. INST. C.E.
T. H. HOUGHTON, M. INST. C.E.	Prof. W. H. WARREN, LL.D., WH.SC.

JUNE 2nd, 1915.

The three hundred and seventy-third General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. R. Greig-Smith, President, in the Chair.

Twenty-six members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of four candidates for admission as ordinary members were read: three for the second, and one for the first time.

Judge DOCKER and Mr. W. WELCH were appointed Scrutineers, and Mr. H. G. SMITH deputed to preside at the Ballot Box.

The following gentlemen were duly elected ordinary members of the Society:—

WILLIAM WALTER WATTS, Presbyterian Clergyman, "The Manse," Gladesville.

ALLAN CLUNIES ROSS, B.Sc. Science Master, Church of England Grammar School, North Sydney.

ALBERT JOHN SACH, F.C.S., (formerly in charge o the Technical College, Goulburn), "Kelvedon," North Road, Ryde.

On the motion of Professor POLLOCK, seconded by Dr. CHAPMAN, it was resolved—That members on Active Service be exempted from the payment of annual subscriptions during the period of such service without loss of any of the rights of membership.

The President announced that a Popular Science Lecture would be delivered by Mr. D. G. STEAD, F.L.S., on the 17th June, entitled "Whales and Whaling in Australian Seas."

The death was announced of Mr. G. D. HIRST, F.R.A.S., an old member of this Society, and it was resolved that a letter of sympathy be sent to his relatives.

A letter was read from Mr. A. GIBB MAITLAND, F.G.S., expressing his appreciation of the honour which the Society had conferred upon him in electing him an Honorary Member.

Mr. G. C. DU FAUR wrote thanking the Society for sympathy in the death of his father Mr. E. DU FAUR.

A letter was read from Mr. Ivor Onslow Thompson thanking the Society for sympathy in the death of his brother Lieutenant-Colonel A. J. Onslow Thompson, who was killed in action at the Dardanelles.

Eleven volumes, 217 parts, 10 reports and 6 catalogues were laid upon the table.

THE FOLLOWING PAPER WAS READ:

"A note on the occurrence of Urease in Legume nodules and other plant parts," by M. S. Benjamin (Communicated by Mr. F. B. Guthrie).

Remarks were made by Dr. Cleland, Mr. Maiden, Dr. Harker and the President.

EXHIBITS:

1. A model showing the path of the present Comet (Mellish) in the Solar System, by Professor W. E. Cooke.

2. Samples of fifty-one species and varieties of Acacia seeds and seedlings, in various stages of development, by Mr. E. Cheel.

JULY 7th, 1915.

The three hundred and seventy-fourth General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth Street, Sydney, at 8 p.m.

Dr. Greig-Smith, President, in the Chair.

Twenty-seven members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of two candidates for admission as ordinary members were read: one for the second, and one for the first time.

Mr. G. H. Halligan and Mr. A. G. Hamilton were appointed Scrutineers, and Dr. Cleland deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society:—

Robert Kenneth Murphy, Consulting Chemical Engineer and Lecturer in Chemistry, Technical College, Sydney.

The President referred to the death of Mr. F. Manson Bailey, C.M.G., etc., Colonial Botanist of Queensland, and a Clarke Memorial Medallist of this Society, and on the motion of Mr. Maiden it was resolved that a letter of sympathy be forwarded to the members of his family.

The President also announced the death of Mr. Lawrence Hargrave who was elected a member of this Society in 1887, and on the motion of Professor Pollock, seconded by Mr. Hedley it was decided that the sympathy of members be conveyed to Mrs. Hargrave.

A letter was read from Mrs. G. D. Hirst thanking the Society for sympathy in the death of her husband.

Seventy-six parts, 6 reports, and 1 map were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "Acacia Seedlings," Part I, by R. H. Cambage, F.L.S. Remarks were made by Mr. A. G. Hamilton, Dr. Cleland, Messrs. Maiden, Cheel, Baker and the President.

2. "Some notes on *Blechnum capense*, with description of a new variety," by Rev. W. Walter Watts.

3. "The Mosses of the New Hebrides," by Dr. V. F. Brotherus and Rev. W. Walter Watts.

EXHIBIT:

Dr. J. B. Cleland and Mr. E. Cheel exhibited specimens of two European Fungi, *Pholiota adiposa* and *Fistulina hepatica*, found at Mount Wilson, Blue Mountains, and not hitherto recorded for New South Wales. Remarks were made by Mr. Maiden.

(1) *Pholiota adiposa,*—This handsome species, with an orange-yellow glutinous cap and brown gills, is recorded as a destructive timber-parasite in Europe. Several smooth-barked trees, probably Coachwood, were found close together in dense brush at Mount Wilson in June bearing the fruiting bodies. These were attached to the upright trunk, some near the ground and others out of reach twenty or thirty feet up. The mycelium spreading through the wood, renders this useless, whilst the health of the tree is affected. Annually the fruiting caps appear, growing from the perennial mycelium, thus by liberating their spores tending to distribute the parasite. The attention of the Director of Forests has been drawn to the occurrence of this possibly dangerous parasite, and it is to be hoped that effective measures may be taken to eliminate it before any economic loss occurs. This fungus has not hitherto been recorded for Australia.

(2) *Fistulina hepatica.*—The Beef-steak Fungus, an edible polypore that occurs in Europe. This was found growing on a fallen log. The tubes of one specimen were pinkish, of the others yellowish, when gathered. Hitherto only recorded in Australia from Western Australia. Six species of *Fistulina* are known; of these one is recorded from the Caroline Islands, and one on *Fagus* from Patagonia.

The occurrence of these two European species of fungi, hitherto unknown in this State, at Mount Wilson, suggests that they may have been introduced with European plants or their accompanying soil, and, finding the climatic conditions suitable, have been able to obtain a footing. On the other hand their occurrence in Australia may antedate the white man's appearance here, but their distribution may be limited by climatic requirements, thus accounting for their having remained unreported until now in New South Wales.

AUGUST 4th, 1915.

The three hundred and seventy-fifth General Monthly Meeting of the Royal Society of New South Wales was

held at the Society's House, 5 Elizabeth Street, Sydney, at 8 p.m.

Dr. GREIG-SMITH, President, in the Chair.

Twenty-five members were present.

The minutes of the preceding meeting were read and confirmed.

Mr. OLLÉ and Mr. HOOPER were appointed Scrutineers, and Mr. CARMENT deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society:—

HENRY WILLIAM ARMIT, M.R.C.S., L.R.C.P., Editor, "The Medical Journal of Australia, 30 – 34 Elizabeth Street, Sydney.

Letters were read from Mrs. L. HARGRAVE and Mr. J. F. BAILEY thanking the Society for sympathy in their recent bereavements.

The death was announced of Mr. E. R. FAIRFAX who was elected a member in 1877.

It was also announced that Mr. F. MARSHALL and Dr. J. F. FLASHMAN had gone on Active Service.

The Honorary Secretaries reported that the Council had approved of the formation of a Section of Public Health and Kindred Sciences, and that the first meeting of the Section would be held on the 14th September.

The President announced that on the 19th August a special lecture by Colonel HUBERT FOSTER, R.E., would be delivered, entitled:—"The Strategy of the War in Europe."

A letter was read from Captain F. WALSH drawing attention to certain awards which were being offered by the Russian Government for inventions in connection with the present war.

One hundred and eighty-one parts, 5 volumes, 8 reports, and 2 maps were laid upon the table.

THE FOLLOWING PAPERS WERE READ.

1. "On the Essential Oil of *Eucalyptus Smithii*, from various forms of Growth," by H. G. SMITH, F.C.S. Remarks were made by the President.

2. "On the Composition of Human Milk in Australia," Part I, by H. S. H. WARDLAW, B.Sc. Remarks were made by Dr. CHAPMAN, Professor FAWSITT and the President.

3. "Notes on Australian Fungi," No. 2, by J. B. CLELAND, M.D., Ch.M., and E. CHEEL.

4. "Description of New Australian Blood-sucking Flies belonging to the family Leptidæ," by EUSTACE W. FERGUSON, M.B., Ch.M. (Communicated by J. B. CLELAND, M.D.)

SEPTEMBER 1st, 1915.

The three hundred and seventy-sixth General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. GREIG-SMITH, President, in the Chair.

Thirty-six members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

The President made the following announcements:—

1. That the Council had been considering the question of local scientific assistance in connection with the present war, and a copy of the following resolution had been forwarded to the Premier:—"That the Council of the Royal Society offers the services of the Society to the Government, in connection with any scientific matter arising out of the present war, on which the Government desires its assistance."

2. The Council had also decided "that a circular be issued to the members of the Society drawing attention to the need of special enquiries, and asking them to forward to the Council for transmission to the special Committees any suggestions or results of investigations that they consider may be useful at the present time."

3. That a Popular Science Lecture, entitled "Plant Life in the Sea," would be delivered by Professor A. ANSTRUTHER LAWSON, on the 16th September.

4. That the Inaugural Meeting of the Section of Public Health and Kindred Sciences would be held on the 14th September.

5. That donations of 83 parts, 4 volumes, 4 reports, and 1 map had been received during the month.

THE FOLLOWING PAPER WAS READ:

"The Age of the Southern Coal Field Tableland Basalts," by L. F. HARPER, F.G.S. Remarks were made by Messrs. SUSSMILCH and BENSON.

EXHIBITS:

1. Specimens of Khaki dyes with myrticolorin, the dye of the Eucalypts, by H. G. SMITH, F.C.S.

Mr. SMITH exhibited samples of this dye material, together with specimens of wool dyed with it. These were dyed by Mr. J. A. EASTWOOD, at the Australian Woollen Mills, Marrickville, and clearly demonstrated the efficacy of this material for the purpose of Khaki dyeing. When it is considered that the leaves of this particular Eucalypt contain myrticolorin to the extent of over 8 per cent., it is at once seen that sufficient material is available in New South Wales to satisfy all the requirements of Australia for this purpose. Myrticolorin, which was discovered at the Technological Museum, is a glucoside of quercetin and is readily extracted from the finely powdered leaves, as it is soluble in hot water, although almost insoluble in cold water.

2. Photograph of the Moon, by J. NANGLE, F.R.A.S.

3. Various forms of *Acacia discolor*, also specimens with notes of *Eruca sativa*, *Hibiscus esculentus*, *Taraxacum officinale*, *Peucedanum graveolens* and *Fœniculum vulgare*, by E. CHEEL.

The specimens of *Acacia discolor* Willd., showed considerable variation, and suggested that it may be possible to separate the forms under distinct names as originally described by Bentham. The forms may be briefly described as follows :—

(1) Branches nearly terete, the young branches thickly clothed with pubescence. Specimens which agree with the above description were collected by Banks and Solander in 1770, and from Port Jackson by R. Brown in 1802 – 1805; Centennial Park, E. Cheel, July, 1898; Bullahdelah, J. L. Boorman, August, 1911; Bellingen, Assistant Forester Swain, March, 1910. The above agree with the description given in Bot. Mag. t. 1750; Benth. in Hook. Lond. Journ. Bot., i, p. 384; DC., Prodr. ii, p. 468, and Don in Hist. of Gard. and Bot., ii, p. 419.

(2) Branches more or less angular and quite glabrous. Specimens which agree with the above description are much more common, having a wide range from Port Jackson to the Blue Mountains and Southern Tablelands into Victoria and Tasmania. It is interesting to note that plants of this form may be found with very pale yellow coloured flowers growing side by side with those plants producing the normal darker yellow ones.

These seem to agree with the description of *A. discolor* Willd. var. *Fraseri* Benth., in Hook. Lond. Journ. Bot., i, p. 384, which he appears to have suppressed, as the name does not appear in his "Flora Australiensis." The description of *A. maritima* Benth. *l.c.* also agrees with this form, and it would appear to be advisable to adopt the name *Fraseri* as a varietal name in preference to *maritima* for this series.

A. discolor Willd. var. (?) *angustifolia* Benth., Fl. Aust., ii, p. 414. Specimens in the National Herbarium from Conjola, W.

Heron, April, 1898, and May, 1899, and Bolaro Track, near Braidwood, W. Baeuerlen, May, 1890, have much narrower and more numerous leaflets, and may belong to this variety.

The Council having authorised a discussion on the subject of Medicinal Plants rendered scarce in Australian markets owing to the war, Mr. J. H. Maiden was called upon by the President to open the discussion.

The plants that he brought under review were Buchu (*Barosma spp.*), Belladonna (*Atropa belladonna*), Lobelia (*L. inflata* and other species), Broom (*Cytisus scoparius*), Henbane (*Hyoscyamus niger*), Foxglove (*Digitalis purpurea*), Dandelion (*Taraxacum officinale*), Chiretta (*Ophelia chirata*), Senna (*Cassia spp.*), Rue (*Ruta graveolens*), Savin (*Juniperus sabina*), Horehound (*Marrubium vulgare*).

Taking the list, Mr. Maiden pointed out that most of them could be grown in one part or other of New South Wales, but quoted the writings of E. M. Holmes, Dr. F. V. Kilmer, and others, pointing out the economic difficulties in the way which were additional to the methods and uncertainties of cultivation.

He recommended the employment of trained gardeners for special work such as this, and considered that it was desirable that the Government by means of its Experiment Farms should undertake preliminary work in regard to the cultivation and preparation for market of drugs as an object lesson to our people.

Mr. Fred. Wright, of Messrs. Elliott Bros., was present by invitation, and addressed the members in a very interesting way. He pointed out that in a number of cases the prices of drugs had gone up to such a great height that the prospect of successful cultivation in Australia seemed to be very favourable.

Further remarks were made by Messrs. R. T. Baker and E. Cheel.

OCTOBER 6th, 1915.

The three hundred and seventy-seventh General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. GREIG-SMITH, President, in the Chair.

Twenty-six members were present.

The minutes of the preceding meeting were read and confirmed.

The Pesident announced that through the instrumentality of Mr. J. H. MAIDEN, a very fine portrait of Sir EDWARD DEAS THOMSON, a former Vice-President, had been received from his son, Mr. E. R. DEAS THOMSON.

It was also announced that Mr. H. B. TAYLOR's name had been added to the list of members who had gone on Active Service, and that Dr. E. S. STOKES had returned from the front owing to illness.

Sir J. J. THOMSON wrote expressing his thanks for having been elected an Honorary Member of this Society.

One hundred and thirty-three parts, 8 volumes, 9 reports and 2 maps were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "A note on the Relation between the Viscosity and the Thermal Conductivity of Gases, with reference to Molecular Complexity," by Professor J. A. POLLOCK, D.Sc.

2. "The Wave-length of the Electrical Vibration associated with a thin straight terminated Conductor," by Professor J. A. POLLOCK, D.Sc.

EXHIBIT:

Mr. J. H. MAIDEN exhibited three glass tanks of aquatic plants, viz.:—*Aponogeton fenestralis* Hook., f. (Aponogetonaceæ), Madagascar; *Potamogeton ochreatus* F.v.M.

(Potamogetonaceæ), N.S. Wales; *Vallisneria spiralis* Linn. (Hydrocharitaceæ), N.S. Wales, in order to draw attention to the collection of such plants in the Botanic Gardens. He observed that at that institution there is a fine collection of such plants which cannot be exhibited to the general public since there is no house available for their display, but he cordially invited members of the Society to inspect them, and pointed out that the study of aquatic life was charming alike from the beauty of the vegetation itself, and also because of the facility for the examination of plants which, from their environment, are not so accessible to students as most other plants.

NOVEMBER 3rd, 1915.

The three hundred and seventy-eighth General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. Greig-Smith, President, in the Chair.

Thirty-two members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificate of one candidate for admission as an ordinary member was read for the first time.

The President announced the death of Mr. Josiah Mullens who was elected a member of this Society in 1877.

It was also announced that Professor David's name had been added to the list of members who had enlisted for Active Service.

Donations consisting of 4 volumes, 104 parts and 2 reports were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "The Grey Mangrove *(Avicennia officinalis)*," by R. T. Baker, F.L.S. Remarks were made by Dr. Murphy,

Messrs. J. NANGLE, A. G. HAMILTON, C. HEDLEY, J. H. MAIDEN and the President.

2. "The Origin of the Heliman or Shield of the Coast Aborigines, N.S. Wales," by THOMAS DICK, (communicated by R. T. BAKER).

3. "Cerussite Crystals from Broken Hill, N. S. Wales and Muldiva, Queensland," by Dr. C. ANDERSON.

4. "Notes on Eucalyptus (with descriptions of new species) No. IV," by J. H. MAIDEN, F.L.S. Remarks were made by Mr. BAKER.

EXHIBITS.

1. Specimens and Micro-slides showing structure of leaves, timber and bark of the Grey Mangrove (*Avicennia officinalis*) by R. T. BAKER.

2. Professor DAVID sent a specimen of *Metœrinus cyaneus*, Clark, dredged by a State Trawler off the coast south of Sydney, and forwarded to him by Mr. MURRAY SINCLAIR.

DECEMBER 1st, 1915.

The three hundred and seventy-ninth General Monthly Meeting of the Royal Society of New South Wales was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. GREIG-SMITH, President, in the Chair.

Forty-four members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of candidates for admission as ordinary members were read: one for the second, and two for the first time.

Mr. CARNE and Dr. HARKER were appointed Scrutineers, and Mr. NANGLE deputed to preside at the Ballot Box.

The following gentleman was duly elected an ordinary member of the Society:—

THOMAS DICK, Merchant, Port Macquarie.

Mrs. E. R. FAIRFAX and Mr. A. L. MULLENS wrote thanking the Society for sympathy in ther recent bereavements.

Four volumes, 113 parts, 5 reports and 2 calendars were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "The Geology of the Jenolan Caves District," by C. A. SUSSMILCH, F.G.S., and W. G. STONE. Remarks were made by Professor WARREN and Mr. E. C. ANDREWS.
2. "Two Lord Howe Island Polypodia," by Rev. W. WALTER WATTS.
3. "Notes on the Native Flora of Tropical Queensland," by R. H. CAMBAGE, F.L.S. Remarks were made by Dr. CLELAND and Mr. MAIDEN.
4. "Some Geo-physical Observations at Burrinjuck," by L. A. COTTON, B.A., B.Sc. Remarks were made by Father PIGOT.
5. "Notes on Acacia (with descriptions of new species)," No. 1, by J. H. MAIDEN, F.L.S.
6. "*Eucalyptus australiana* and its Essential Oil," by R. T. BAKER, F.L.S., and H. G. SMITH, F.C.S. Remarks were made by Mr. CAMBAGE, Mr. ANDREWS and Dr. HARKER.

EXHIBITS:

Mr. E. CHEEL exhibited living plants of *Acacia intertexta* Sieb., and *A. longifolia* Willd., showing further development since the December, 1914 meeting, when a series of specimens were exhibited. (See this Journal XLVIII (1914) xxii.)

The juvenile plants of *A. intertexta* show the same characteristic thick leathery phyllodes of the parent plants, and it is noticeable that each phyllode is of a bright purplish-red colour at first, which

gradually becomes greenish as the phyllodes reach maturity. The growth of the plants is much slower than those of *A. longifolia*.

He also exhibited herbarium specimens of different forms of *A. juniperina* as follows :—

The Spit, Sydney, Dr. J. B. Cleland, July, 1911.
Hill Top, E. Cheel, September, 1913.

These show very prominent spinescent bracteoles between the unexpanded flowerets, which no doubt prompted the name *A. echinula* DC. for these forms.

Wiseman's Ferry, Dr. J. B. Cleland, August, 1915.
Como, E. Cheel, August, 1900.

These specimens are perfectly glabrous, the flowers a richer yellow and belong to *A. acicularis* R. Br., united with *A. juniperina* under the name var. *Brownei* by Bentham.

GEOLOGICAL SECTION.

ABSTRACT

OF

PROCEEDINGS OF THE GEOLOGICAL SECTION.

Monthly Meeting, 14 July, 1915.

Mr. R. H. CAMBAGE, in the Chair.

Ten members and three visitors were present.

Apologies for absence were received from Professor DAVID and W. S. DUN.

Professor DAVID and Mr. W. S. DUN were proposed and elected as Chairman and Honorary Secretary respectively.

EXHIBITS:

1. Mr. WATKIN BROWN exhibited specimens of nickeliferous and other ores from Canada and the United States, and a specimen of Wardite.

2. Dr. ANDERSON exhibited zeolites from Ardglen, associated with apophyllite.

3. Mr. W. N. BENSON showed plants and other fossils from the Devonian and Carboniferous rocks of the Currabubula and Werris Creek area—of special interest was the occurrence of *Sphenophyllum.*

4. Mr. E. C. ANDREWS exhibted molybdenite ores from the Yetholme and Whipstick Mines. Unlike many other molybdenite deposits in Eastern Australia, the molybdenite in these areas occurs with massive and crystallized garnets.

Mr. W. N. BENSON described the Devonian and Carboniferous beds of the Currabubula and Werris Creek District. He drew attention to the occurrence of huge pitchstone sills extending N.N.W. and S.S.E. in parallel series for many

miles. Interesting fossils, especially the plant *Sphenophyllum* were exhibited from the sedimentary formations of the district. The topography is peculiar and is determined by the differential erosion of dense sills and weaker sediments, all folded and intruded by numerous dykes.

The area mapped lies south and west of that already described in the Proc. Linn. Soc. N.S.W. In this, as in the more northern and eastern areas the Carboniferous is conformable to the Devonian. Evidence was also brought forward to show the intrusive nature of the Tamworth tuffs.

Monthly Meeting, 8 September, 1915.

Mr. R. H. CAMBAGE, in the Chair.

Seven members and two visitors were present.

EXHIBITS:

1. Mr. W. N. BENSON exhibited specimens illustrating tertiary basalt intrusions into mudstone, showing intense crystallization and the formation of sapphire and anorthite felspar from Skye, Scotland.

2. Judge DOCKER exhibited enlargements of photographs of trachyte plugs and necks at the Warrumbungle Mountains, taken in 1895.

3. Mr. G. H. HALLIGAN exhibited views of the Grand Canyon.

Mr. W. N. BENSON described the volcanic geology of Skye basing his remarks on A. Harker's memoir. He illustrated his remarks by maps, photographs and specimens.

Monthly Meeting, 13 October, 1915.

Mr. R. H. CAMBAGE, in the Chair.

Thirteen members and three visitors were present.

EXHIBITS:

1. Mr. E. C. ANDREWS exhibited specimens of molybdenite from New England, and remarked on the nature of the occurrence.

2. Mr. W. S. DUN exhibited a specimen of *Medusina* from the Cambrian of Sweden.

Mr. E. F. PITTMAN gave notes on experiments conducted with regard to the composition and porosity of the sandstones of the Intake Beds of the Artesian System of Eastern Australia. [Since published by the Department of Mines, Sydney.] A discussion followed.

Monthly Meeting, 10 November, 1915.

Mr. R. H. CAMBAGE, in the Chair.

Eleven members and four visitors were present.

EXHIBITS:

1. Mr. W. N. BENSON exhibited specimens of intrusive tuffs from Tamworth and thin sections.

2. Mr. W. R. BROWNE exhibited a Cycad, closely related to *Pterophyllum*, from Newcastle. The fossil is very similar in general character to *P. distans* of the Upper Gondwanas of India. The specimen is of particular interest as the occurrence of Cycads in the Permo-Carboniferous of Australia has not been recorded since Alexander Berry's remarks in his essay on the geology of the coast of N. S. Wales, in speaking of the cliffs at the entrance to the Hunter River, "I think I have been able to recognise the leaf of the *Zamia spiralis*." (Barron Field, Geographical Memoirs on N.S. Wales, 1825, p. 286).

3. Judge DOCKER exhibited enlargements of photographs taken in the Warrumbungle and Nandewar Ranges and of geological interest, and other views.

4. W. S. DUN exhibited a new species of fish from the Brookvale brick pit.

Mr. E. C. Andrews delivered an address :—

Periods of Folding and Ore Deposition in Australasia and the Associated Islands.

1. With the progress of geological time the great periods of folding in Australasia retreated from the south-west in directions both easterly and northerly. The periods of ore deposition were intimately associated with certain of these periods of folding with the possible reception of the Waihi and associated fields in New Zealand, which appears to have been related to volcanic eruptions.

2. According to Maitland, the great bulk of the plateau of Western Australia appears to consist of crystalline schists and other highly altered rock types, associated with plutonic masses, the general strike of the series being north-west and north-north-west, all being Pre-Cambrian in age. Howchin, David, Carne and others, have described the Cambrian and Ordovician as having a general north-westerly and north-north-westerly trend from South-eastern Australia (south of Sydney, to the north of the Northern Territory. In detail, however, these folds have immense corrugations developed along their general direction of strike. It is possible that this period of folding belongs to the close of the Ordovician. During the Silurian and Devonian times, the Epi-continental seas were greatly extended, and they encroached as far west as the Darling River in New South Wales near Bourke. Both these periods appear to have been closed in Australia with strong folding. A great zone of weakness with a strike almost north-north-west and, stretching from Sydney beyond Narrabri, appears to have divided New South Wales, if not indeed, Australia, into two distinct geological provinces, about the Devonian or earlier period. West and south of this zone, the area of Australia does not appear to have been affected by strong folding movements since the commencement of the Carboniferous, but north and east of this zone, according to Benson, the Devono-Carboniferous sedimentation appears to have been closed by a strong movement of folding, while farther east and north again, the Permo-Carboniferous sediments appear to have been folded strongly along

the peripheral portion of the Continent. The continent of Australasia does not appear to have been affected by strong folding movements in Post-Palæozoic times, nevertheless powerful folding movements, both of Mesozoic and Tertiary age occurs along curves sympathetic with the periphery of Eastern Australia. These features traverse the longer axes of New Guinea, New Caledonia and New Zealand. The latest movement of uplift which affected the areas under consideration appears to have been one of an eperiogenic nature, probably late or Post-Tertiary in age. It was of differential nature, the amount of vertical movement becoming increasingly great, in a direction as from south-west to north and east. Thus there are three plateaux existent, separated by two negative areas, namely, the Great Western Plateau with an average height of little more than 1,000 feet in the south-west; an Eastern plateau varying from 1,700 feet to 7,300 feet high, and farther north and east a New Guinea plateau reaching a height of 15,000 feet, and a much dessicated plateau in New Zealand reaching a height of 12,300 feet.

The Australian plateaux are separated by the central plains, and these in turn are separated from the high New Guinea and New Zealand examples by the deep Coral and Tasman Seas.

A remarkable story is revealed also by a study of the mineral distribution in Australasia and associated regions. Two only are selected here for mention, namely, the gold and tin-wolfram-molybdenite-bismuth groups. The gold deposits in West Australia appear to be of Pre-Cambrian age. In the great belt running through West Tasmania, Bendigo, Ballarat, Cobar, Canbelego, up to a point where it disappears under the great plains, the gold is commonly in 'saddles,' and of an age which may be closing Ordovician, Silurian, or Devonian. Immediately east of the great Hunter zone of weakness, the gold veins are closing Carboniferous in age, according to Benson, while the goldfields east and north of them appear to be closing Palæozoic in age. The Hauraki gold deposits in New Zealand are cited as late Tertiary in age, but unlike the older groups, they do not appear to be associated with

orogenic movements, but instead they appear to be arranged near the foci of volcanic eruptions.

Wolfram, molybdenite and bismuth in Australia are associated with siliceous granites, the tin-wolfram types being characteristically more siliceous than the molybdenite types. Siliceous granite appears to be the original host of the minerals, and the deposits are most frequently arranged within the granites near their intrusive contacts with other rocks, and they occur as 'pipes,' 'veins,' or 'segregations,' but whereas the tin and wolfram frequently leave their host and form deposits in the associated sediments, the molybdenite very rarely forsakes the original granite host.

In Western Australia the tin and molybdenite is of Pre-Cambrian age, and is almost negligible commercially. Similarly for Central Australia. In Tasmania these minerals appear to belong to the close of the Devonian, so also the Victorian and New South Wales areas south of the Hunter zone of weakness. North and east of this zone the tin, wolfram, molybdenite and bismuth deposits belong probably to the close of the Palæozoic. Tin occurs in large amounts in Tasmania, New South Wales, and Queensland, while molybdenite is hardly known in West Australia, it occurs as an ancient deposit in South Australia, but not as yet proved to be commercial. In Tasmania it becomes a little more abundant. In New South Wales south of the Hunter depression it is much more abundant, increasingly so in New England, and also in Northern Queensland. The group has not been recorded except as mineral curiosities from New Zealand.

A study of these fold movements and mineral regions might be expected to throw considerable light on the real geological relations which may exist between New Guinea, New Caledonia, and New Zealand on the one hand, and Australasia on the other. Discussion of such relations, however, is beyond the scope of this brief note.

Messrs. C. A. Sussmilch and W. G. Stone gave an account of their work in connection with the geology of the Jenolan Caves area, which is published *in extenso* in this Journal, pp. 332 - 384.

SECTION OF PUBLIC HEALTH AND KINDRED SCIENCES.

ABSTRACT OF PROCEEDINGS

OF THE

SECTION OF PUBLIC HEALTH AND KINDRED SCIENCES.

The Council of the Royal Society having considered the advisability of forming a section of Public Health, a number of members were invited to meet and consider the question.

The meeting took place at the Royal Society's House, at 4 p.m., on the 8th July, 1915. There were present Dr. Greig-Smith, President of the Royal Society, in the Chair, Dr. H. G. Chapman, Mr. Algernon Peake, Mr. C. Hedley, Dr. Cleland, Mr. R. H. Cambage, and Dr. C. Savill Willis.

The meeting decided unanimously to recommend the Council to form a Section of Public Health and Kindred Sciences.

The following resolutions were passed:—

1. Meetings to be held four times a year.
2. The Section to elect a Chairman and Honorary Secretary.
3. That there be an inaugural meeting at an early date.
4. That Dr. C. Savill Willis be elected Honorary Secretary *pro tem.* to arrange the inaugural meeting.

The inaugural meeting was held at the Royal Society's House, on the evening of the 14th September, 1915. His Excellency the State Governor, Sir Gerald Strickland, and a large number of the members of the Royal Society and visitors were present.

The following Officers of the Section were appointed:—

Chairman—Sir Thomas Anderson Stuart.

Hon. Secretary—Dr. C. Savill Willis.

A discussion on Military Hygiene was opened by the following members, who dealt with that aspect of the subject shown after their names.

Sir T. ANDERSON STUART—The necessity of some organisation for the teaching of Personal Hygiene to men in training.

Mr. ALGERNON PEAKE, M. Inst. C.E.—Water Supply.

Dr. H. G. Chapman — Food Supply.

Mr. HOUGHTON, M. Inst. C.E.—Sanitary Services and disposal of wastes.

Dr. CLELAND—Protection against disease.

After His Excellency the Governor and some other members had contributed to the discussion, the meeting adjourned for a month.

At the adjourned meeting, held at the Royal Society's House, on 12th October, 1915, the discussion on Military Hygiene was continued by various members, including Drs. GUY GRIFFITHS, H. G. CHAPMAN, C. SAVILL WILLIS, and Mr. HOUGHTON. At this meeting, Colonel STOKES, A.A.M.C., gave a very interesting account of Military Hygiene as actually carried out under war conditions at Gallipoli.

The Royal Society is to be congratulated on the successful inauguration of the new Section of Public Health and Kindred Sciences. It is, however, necessary to point out that this Section will almost certainly have a struggle for existence for the next year or so, owing to the fact that many of the Society's members likely to be interested in the Section are at present away with the Expeditionary Forces.

INDEX.

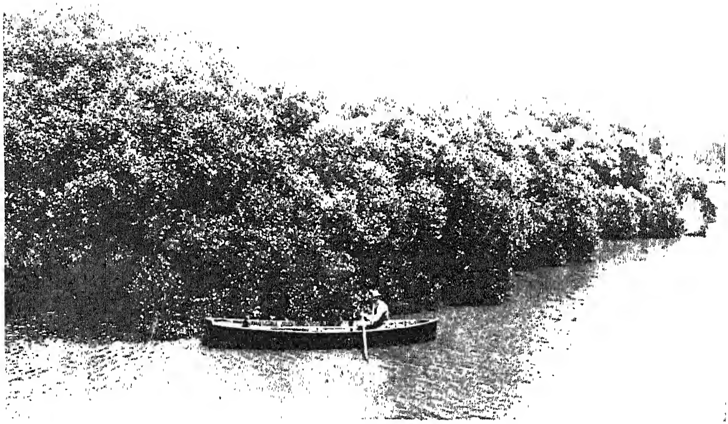
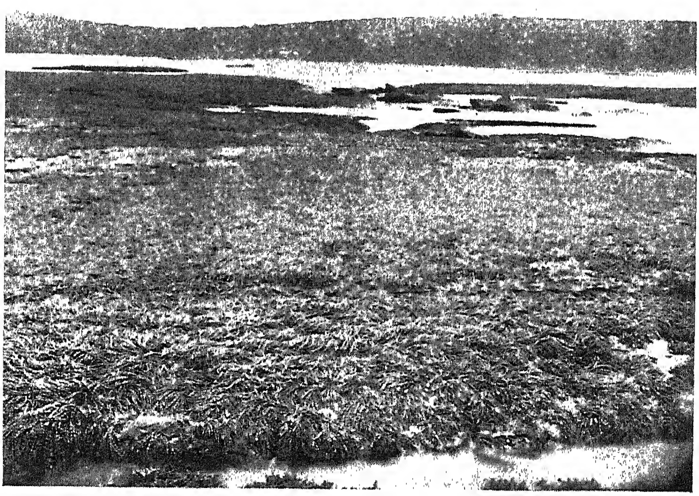


Fig. 1.

A. R. McCulloch, photo.

Fig. 2.

Fig. 3.



A. R. McCulloch, photo.

Fig. 4

Fig. 5.

A. R. McCulloch, photo.

Fig. 6.

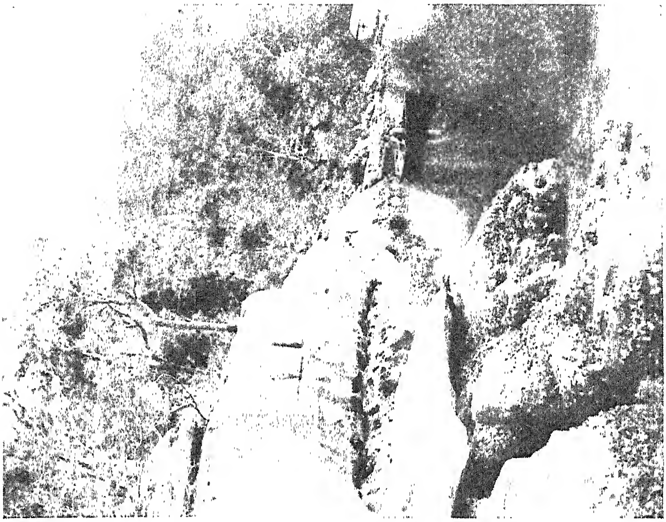


Fig. 8.

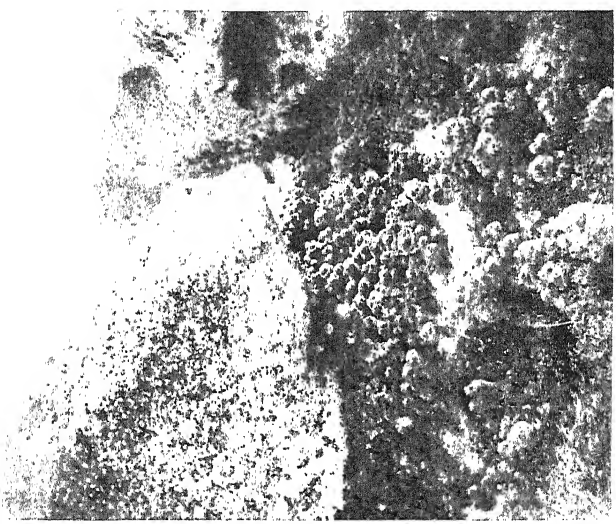


Fig. 7.

A. R. McCulloch, photo.

Fig. 10.

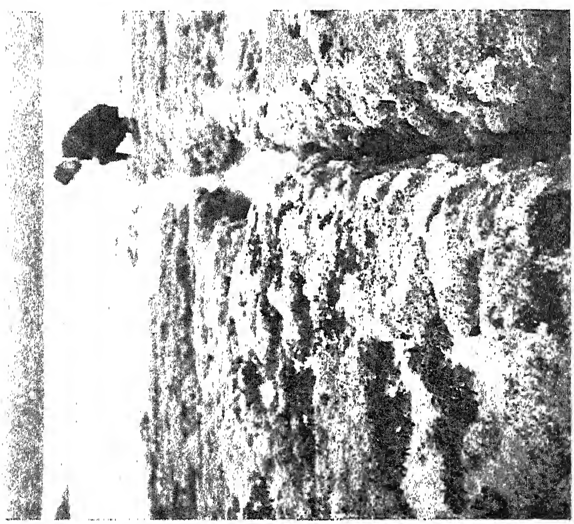
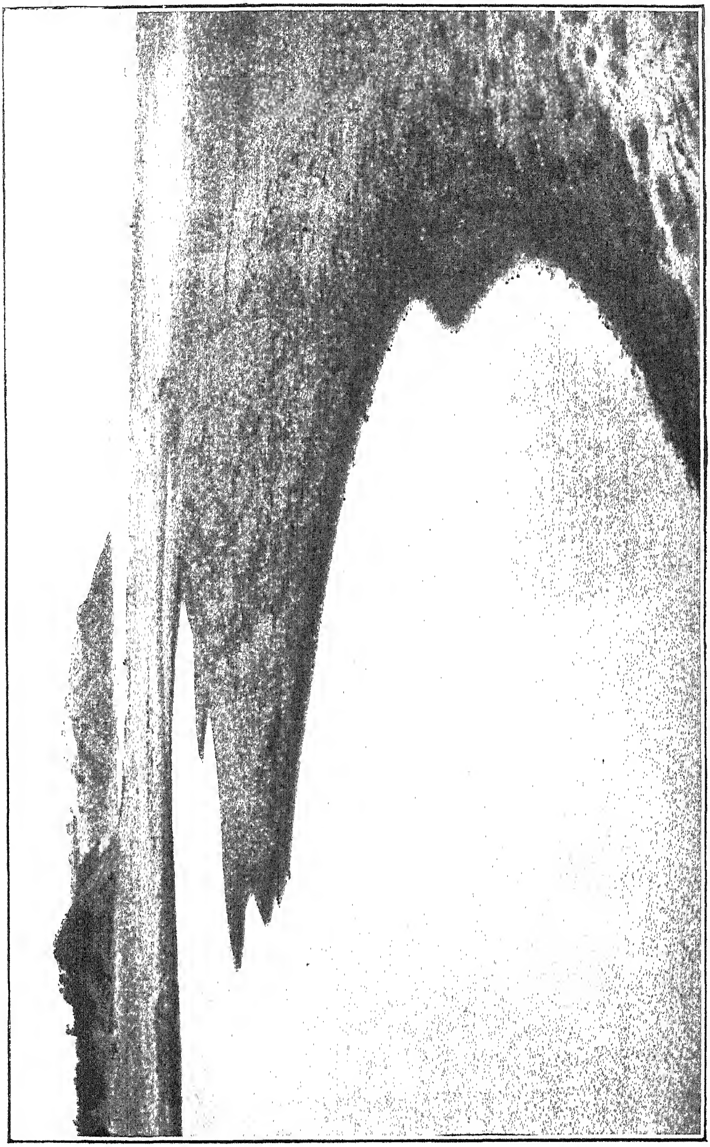


Fig. 9

A. R. McCulloch, photo.



J Degotardi, photo.

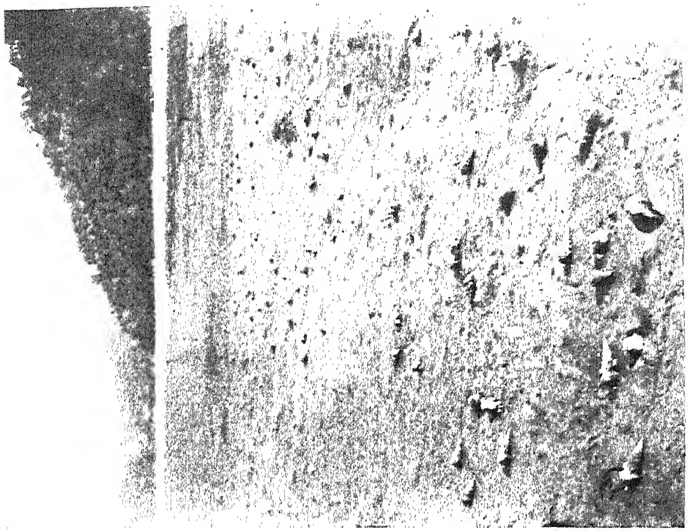


Fig. 12.

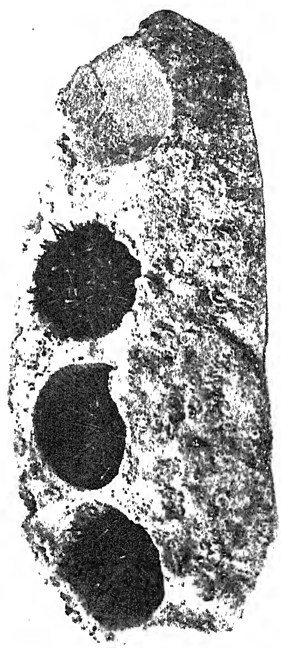
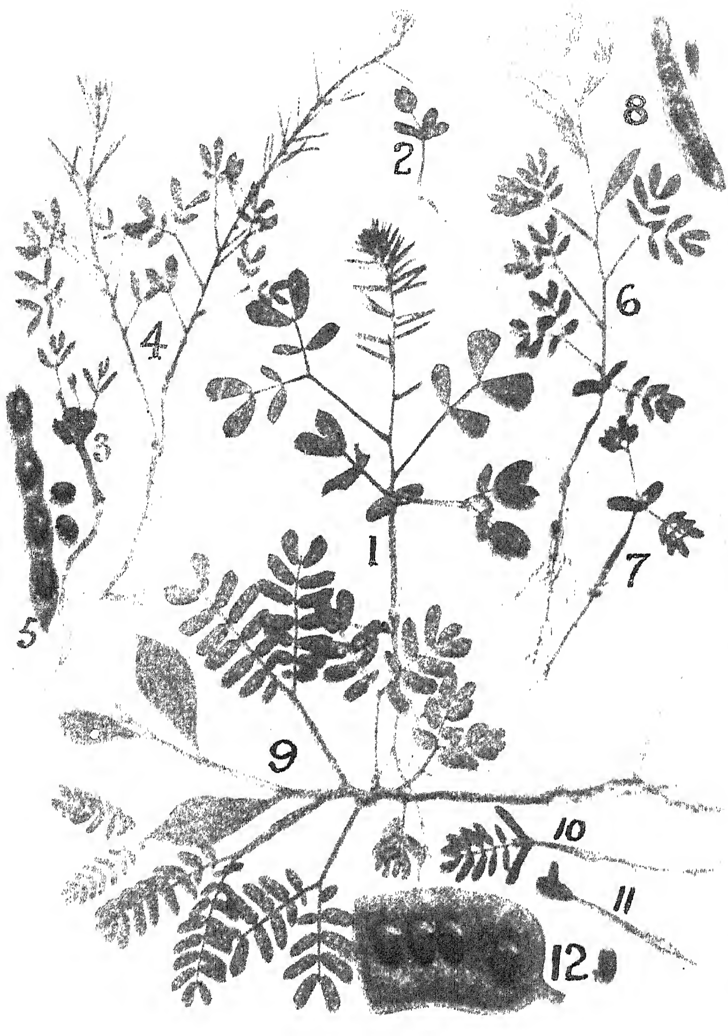
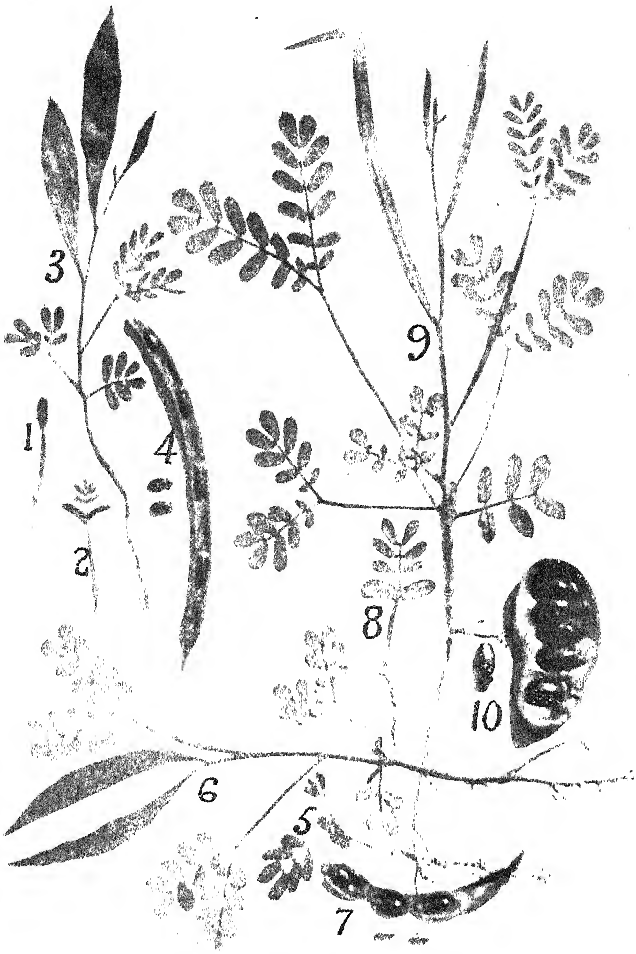


Fig. 11.

A. R. McCulloch, photo.



Acacia juniperina (1 to 5); *A. armata* (6 to 8); *A. undulifolia* (9 to 12).
Nat. size.

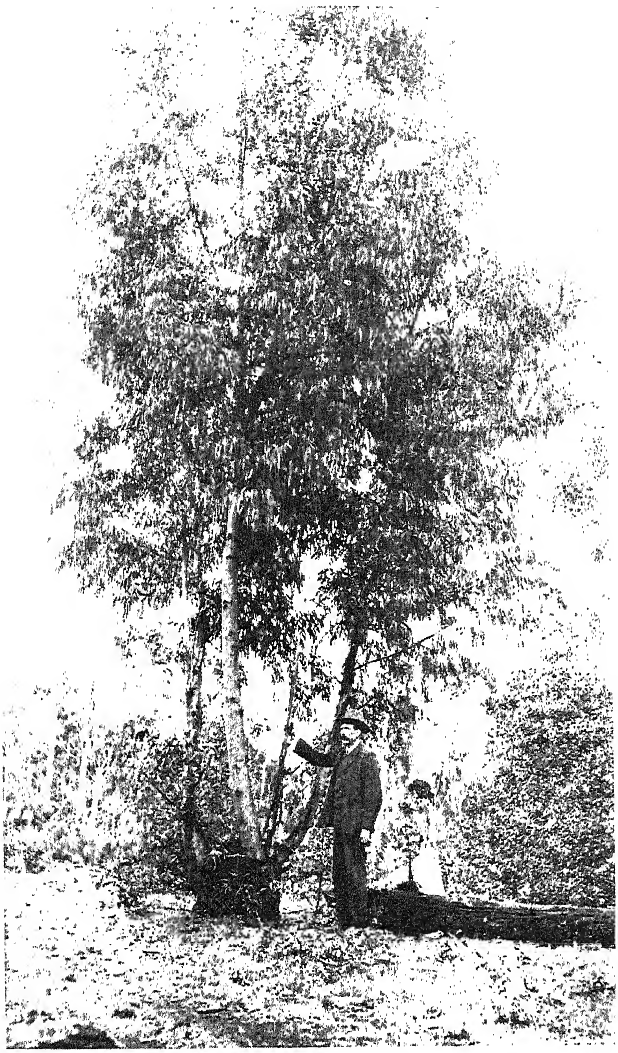


Acacia verniciflua (1 to 4); *A. leprosa* (5 to 7); *A. suaveolens* (8 to 10).
Nat. size.

Acacia prominens (1 to 4); *A. vestita* (5 to 8); *A. Dawsoni*, (9 to 11).
Nat. size.

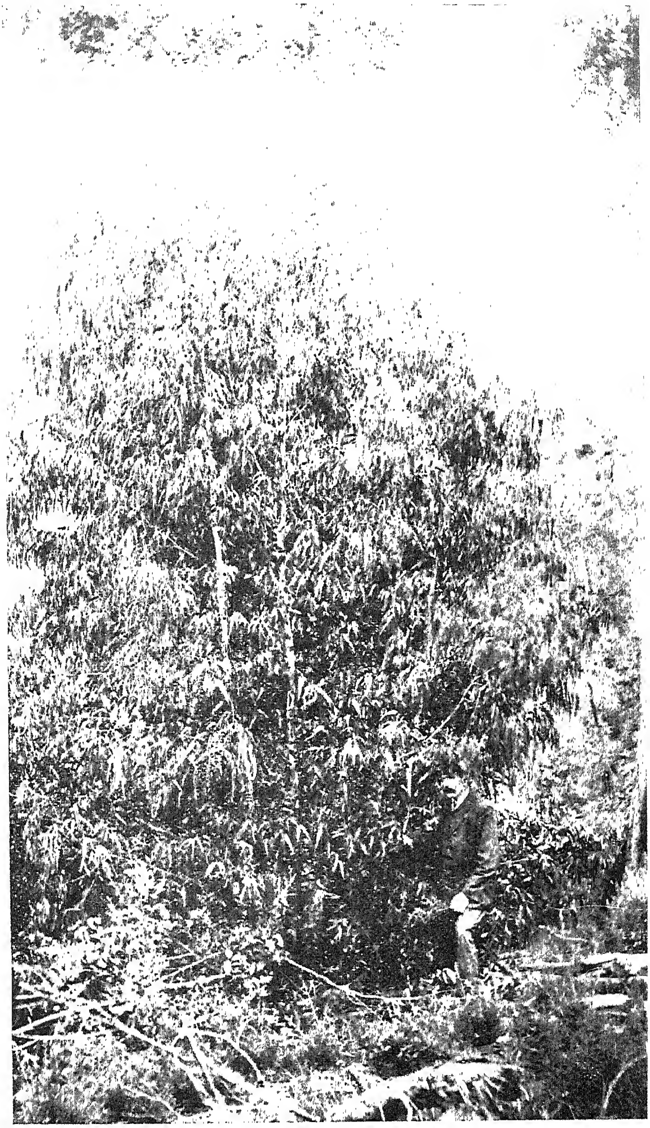
Acacia aneura (1 to 3); *A. glaucescens* (4 to 6); *A. Cunninghamii* (7 to 9).
Nat. size.

Acacia holosericea (1 to 4); *A. Farnesiana* (5 and 6).
Slightly under Nat. size.



Eucalyptus Smithii.

Eucalyptus Smithii.



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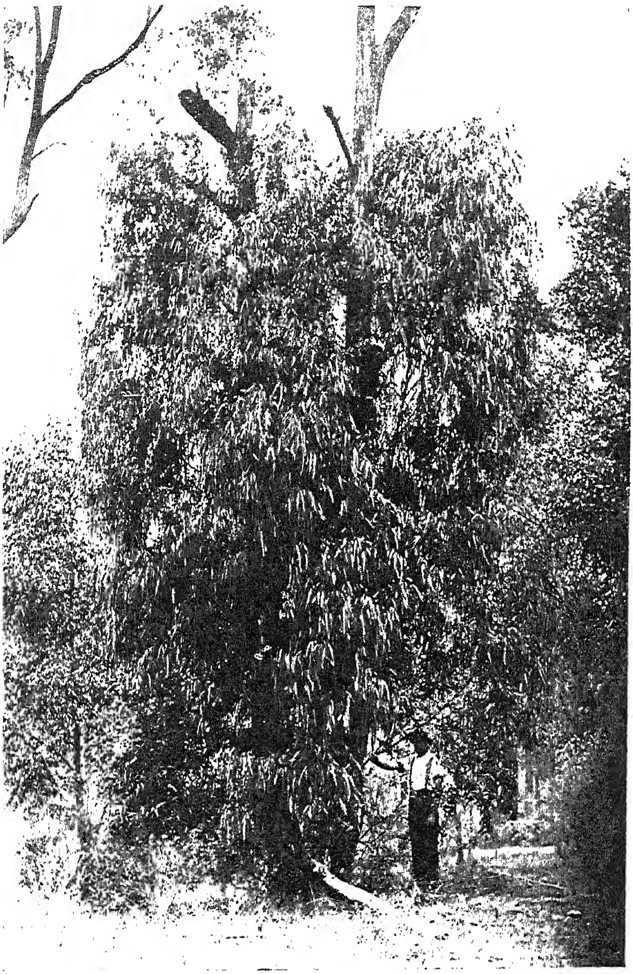
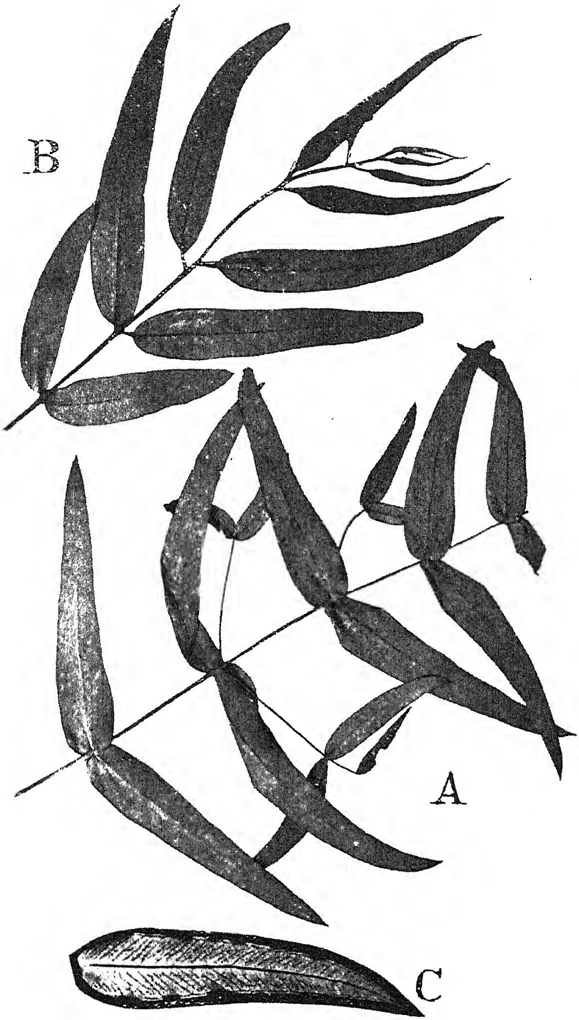


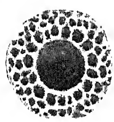
Eucalyptus Smithii.

Eucalyptus Smithii.



Foliage of Eucalyptus Smithii.
Half natural size.

a



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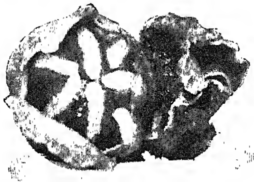

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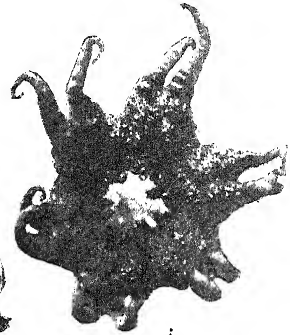

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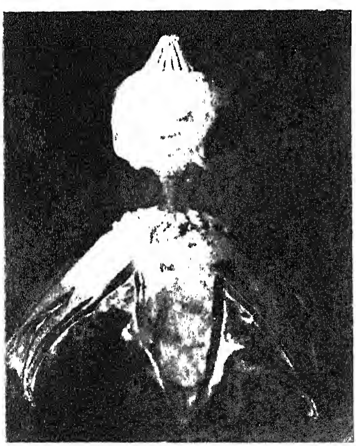

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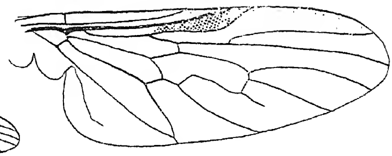

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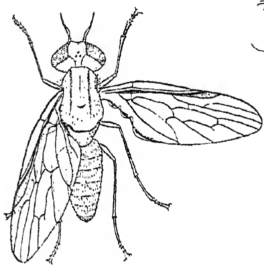

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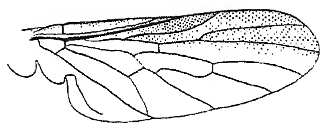

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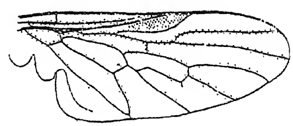

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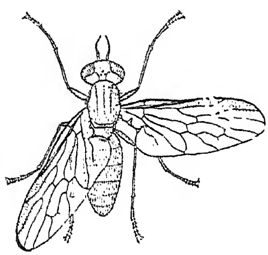

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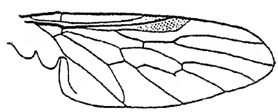

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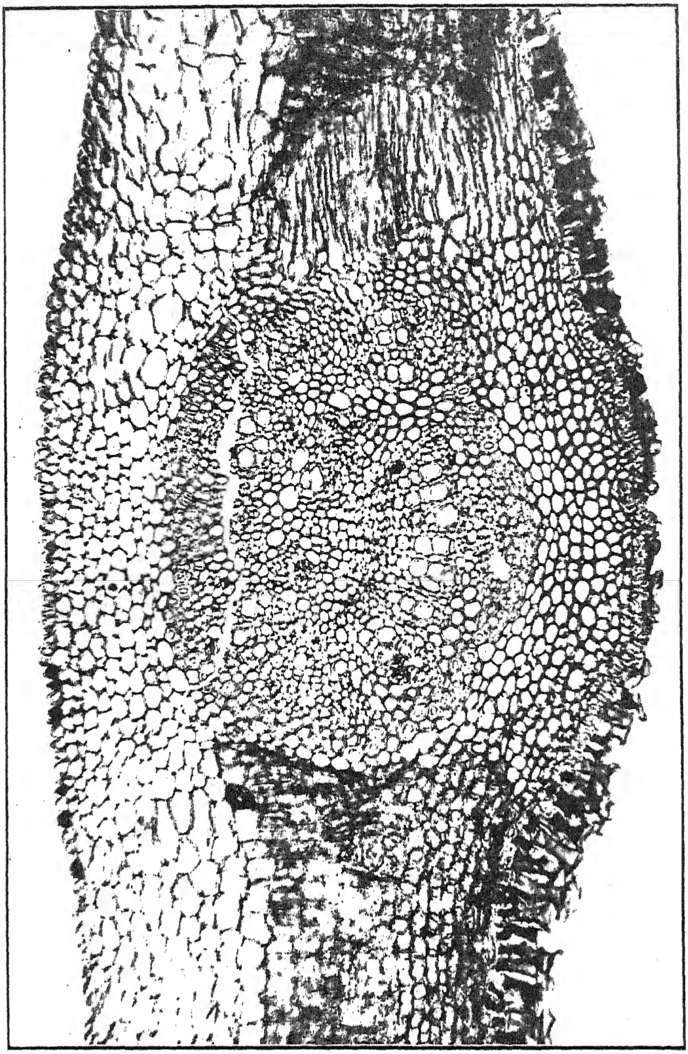
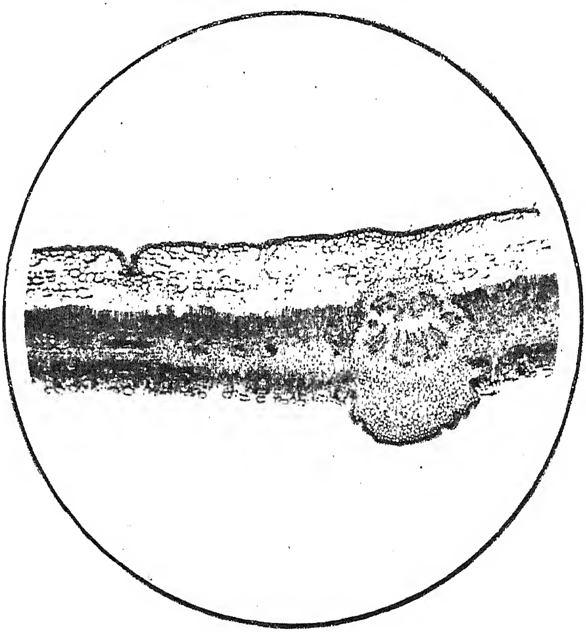


T. C. Roughley, Photo.

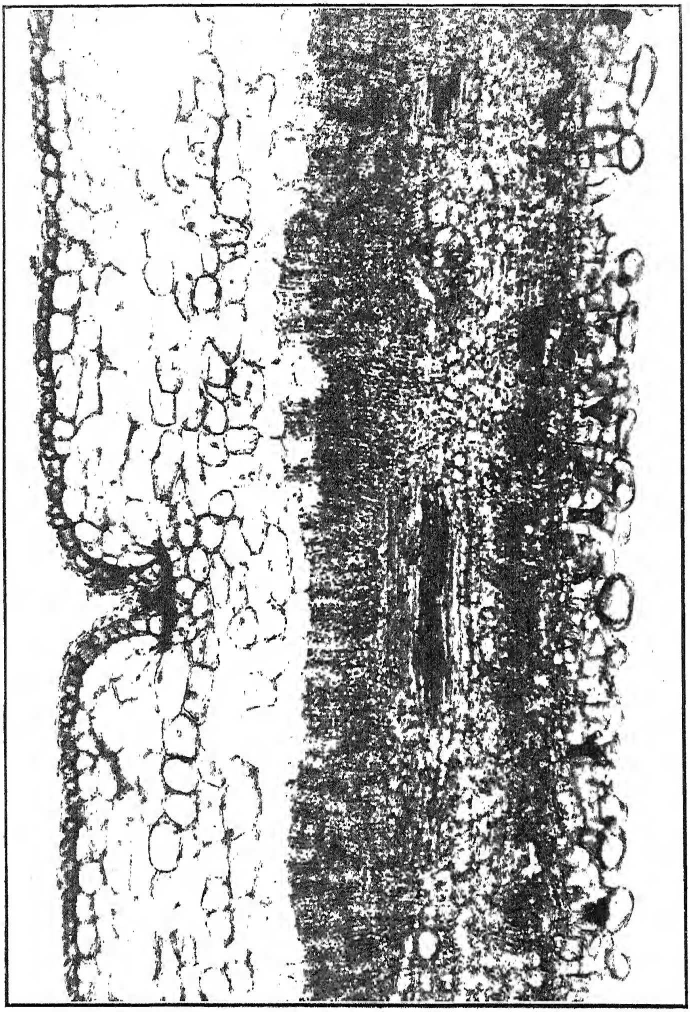
Fig. 1.—Transverse section of a portion of leaf showing central bundle and neighbouring tissue. × 150.

Avicennia officinalis, Linn.



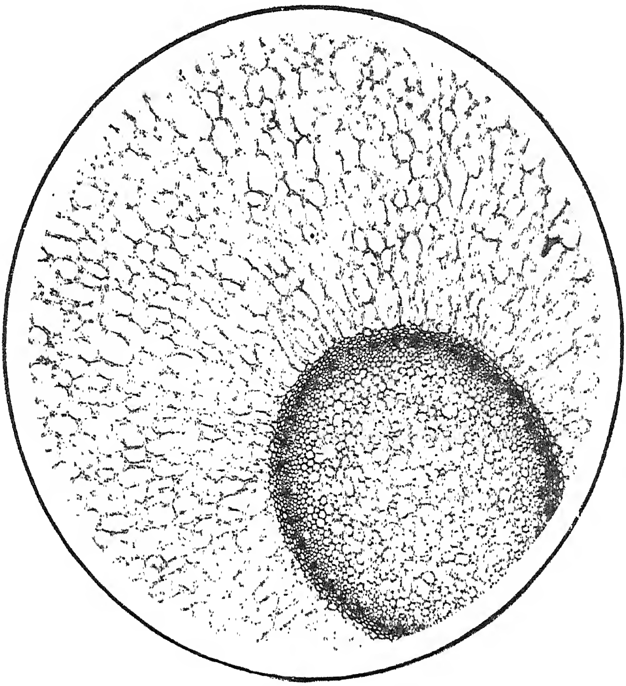
T. C. Roughley, Photo.

Fig. 2.—Transverse section of a portion of leaf showing a depression on the upper surface. × 50. *Avicennia officinalis*, Linn.



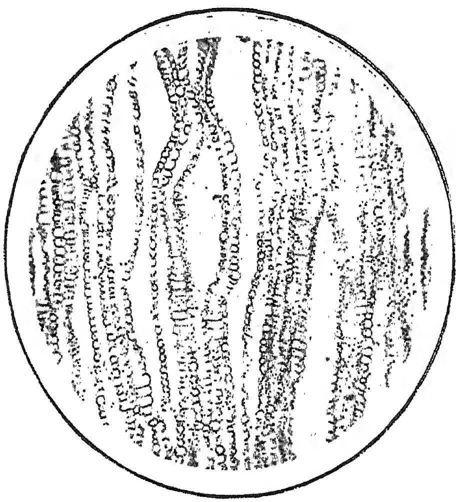
T. C. Roughley, Photo.

Fig. 3.—Portion of Fig. 2 showing structure of depression and surrounding tissue. × 150. *Avicennia officinalis*, Linn.



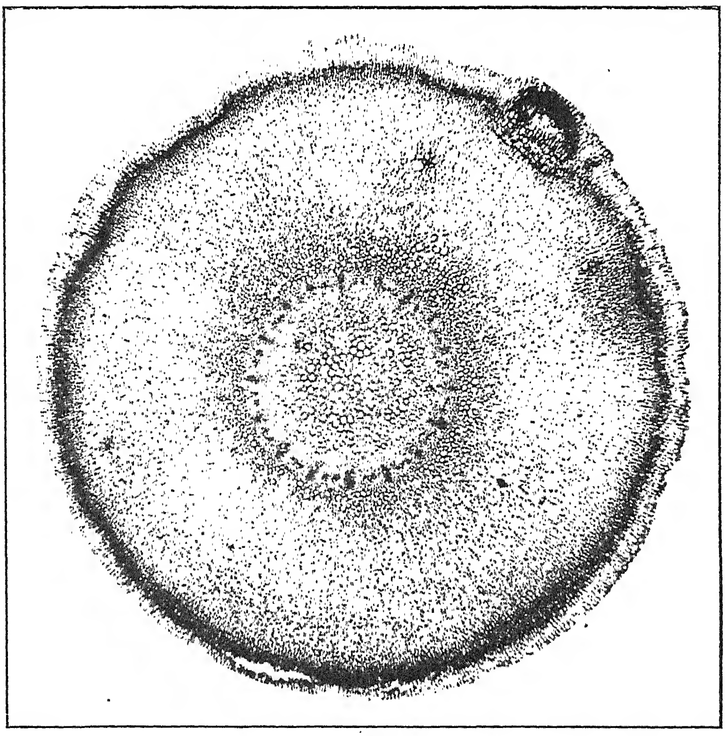
T. C. Roughley, Photo.

Fig. 4.—Transverse section through a pneumatophore below the mud surface. × 30. *Avicennia officialis*, Linn.



T. C. Roughley, Photo.

Fig. 5.—Longitudinal section of primary cortex portion of a pneumatophore below the mud surface. × 15. *Avicennia officinalis*, Linn.



T. C. Roughley, Photo.

Fig. 6.—Transverse section near tip of exposed portion of a pneumatophore, but cutting central root. $\times$ 30. *Avicennia officinalis*, Linn.

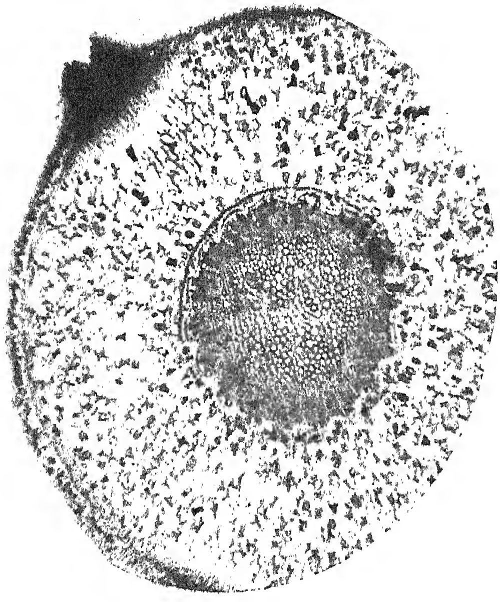


FIG. 7. TRANSVERSE SECTION NEAR THE TOP OF EXPOSED PORTION ABOVE THE MUD OF A PNEUMATOPHORE, BUT CUTTING CENTRAL ROOT LOWER DOWN THAN THAT SHOWN IN FIG 4. ON THE LEFT IS PORTION OF A PNEUMATHODE IN SECTION. X 30.

AVICENNIA OFFICINALIS, LINN.

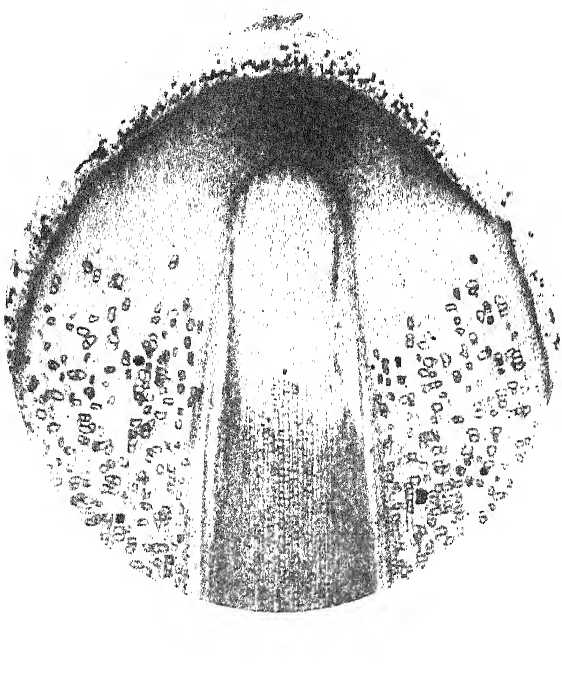
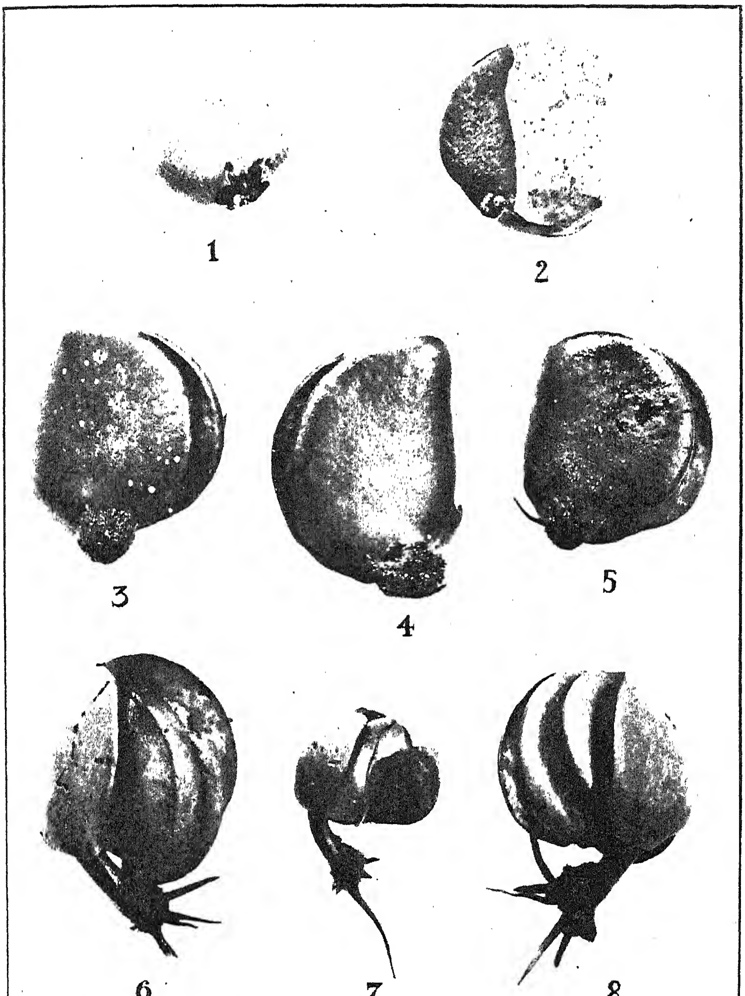


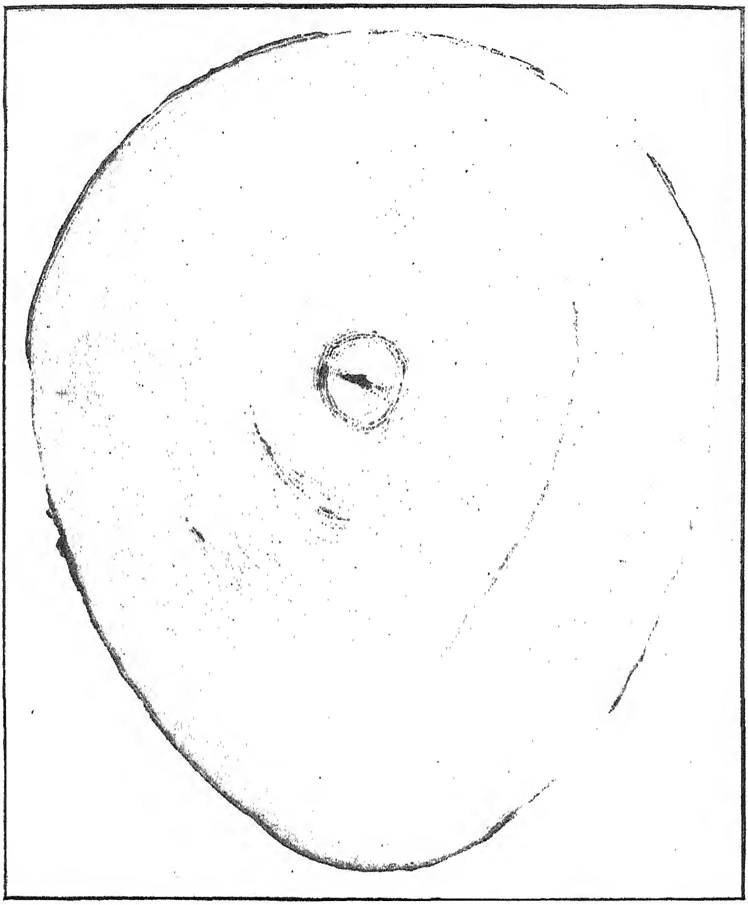
FIG. 8. LONGITUDINAL SECTION THROUGH TIP OF A PNEUMATOPHORE. x 30.

AVICENNIA OFFICINALIS, LINN.



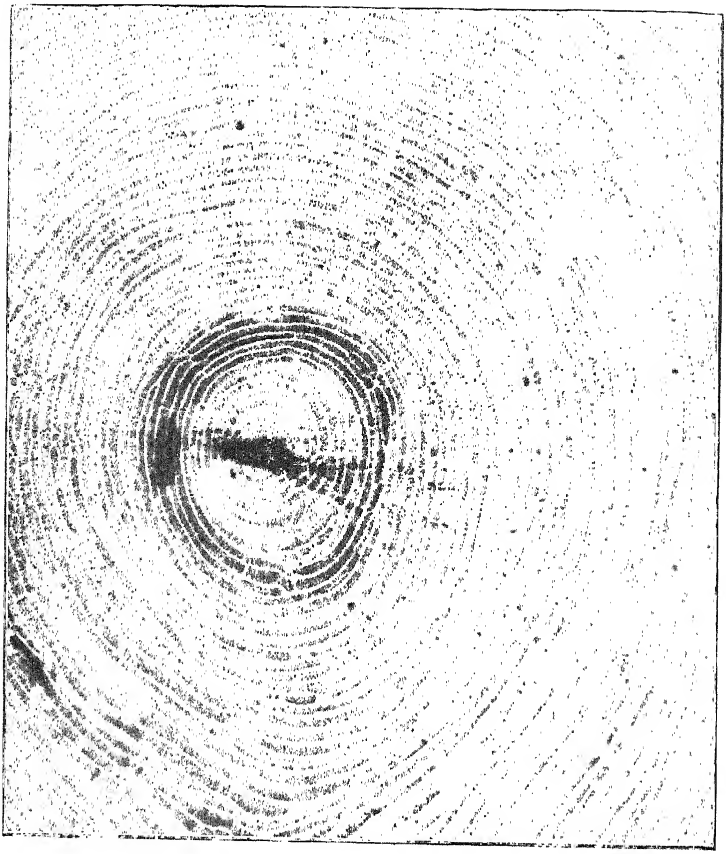
T. C. Roughley, Photo.

Fig. 9.—Series showing germination of seed (natural size). *Avicennia officinalis*, Linn.



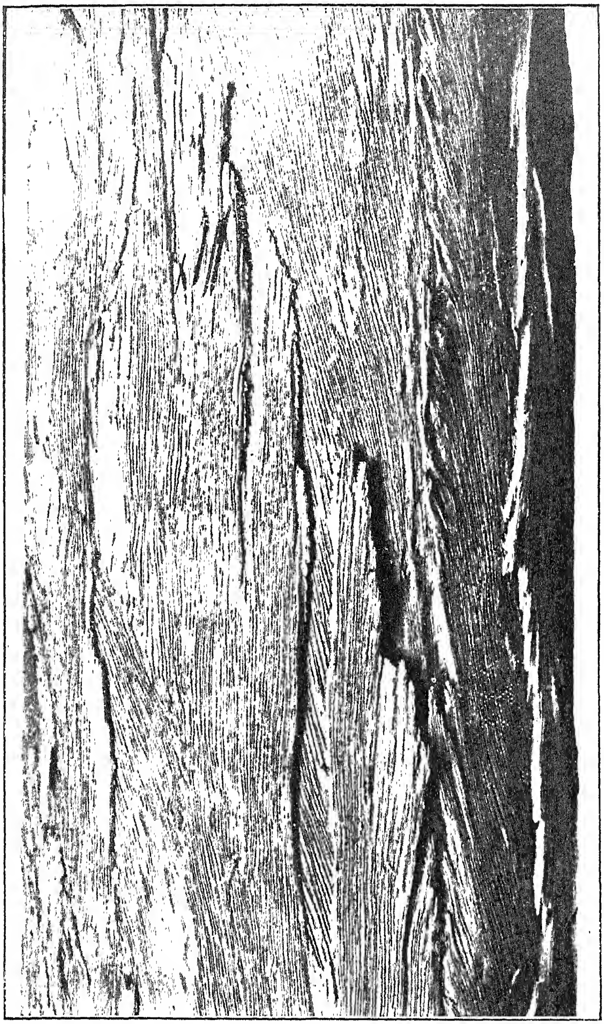
T. C. Roughley, Photo.

Fig. 10.—Transverse section of trunk of tree (reduced). *Avicennia officinalis*, Linn.



T. C. Roughley.

Fig. 11.—Portion of transverse section of trunk of tree enlarged from Fig. 10.
Avicennia officinalis, Linn.



T. C. Roughley, Photo.

Fig. 12.—Section of wood split tangentially, showing disposition of fibres. *Avicennia officinalis*, Linn.

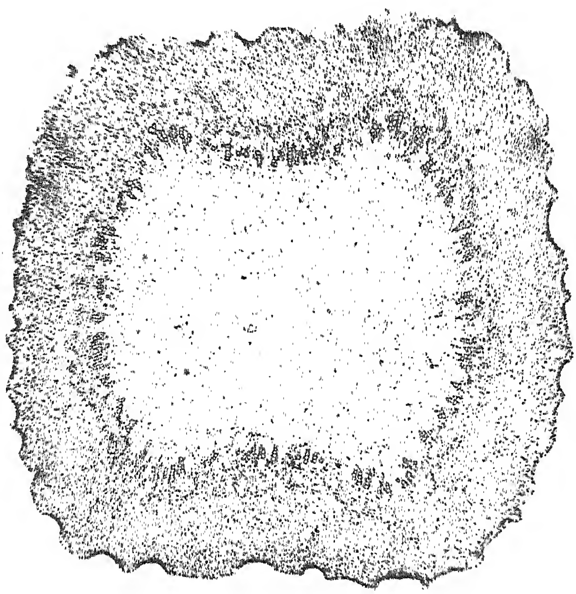


FIG. 13. TRANSVERSE SECTION OF PRIMARY GROWTH x 30.

AVICENNIA OFFICINALIS, LINN

T. C. Roughley, Photo.

Fig. 14.—Transverse section of later growth than Fig. 13. × 100.
Avicennia officinalis, Linn.

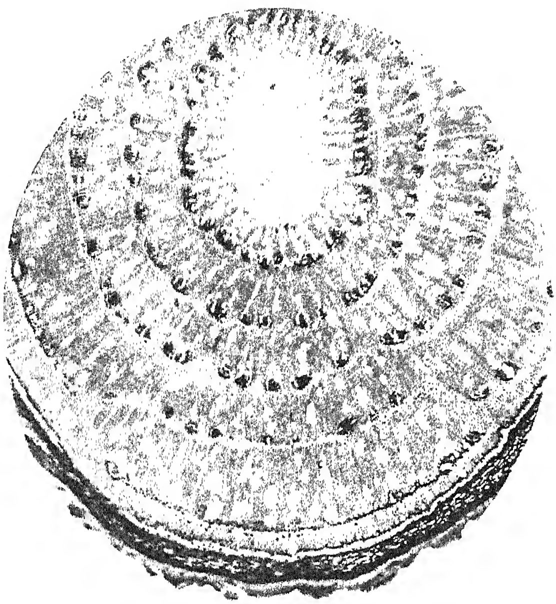
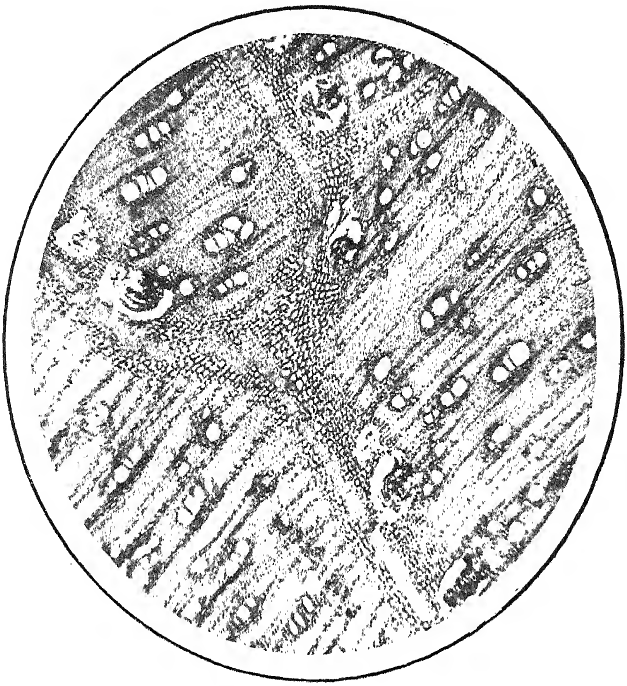


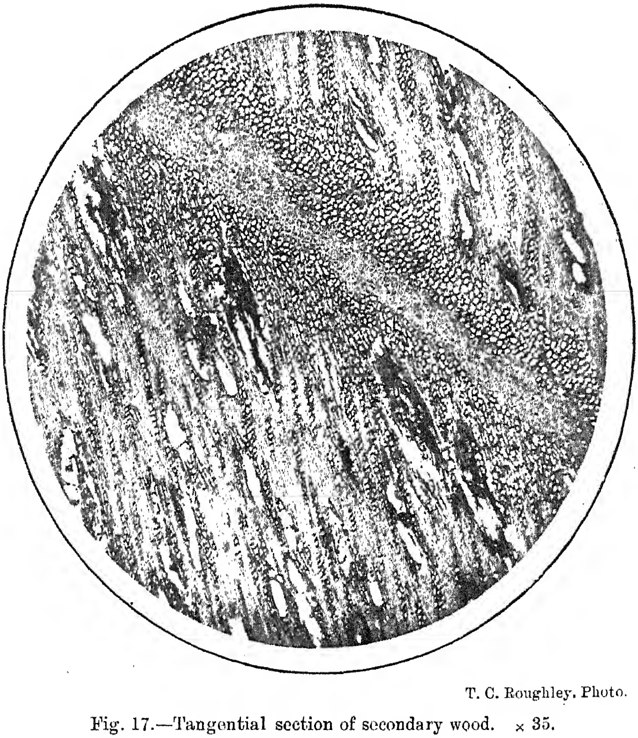
FIG 15. TRANSVERSE SECTION FROM A 6 YEARS OLD STEM. x 15.

AVICENNIA OFFICINALIS, LINN.



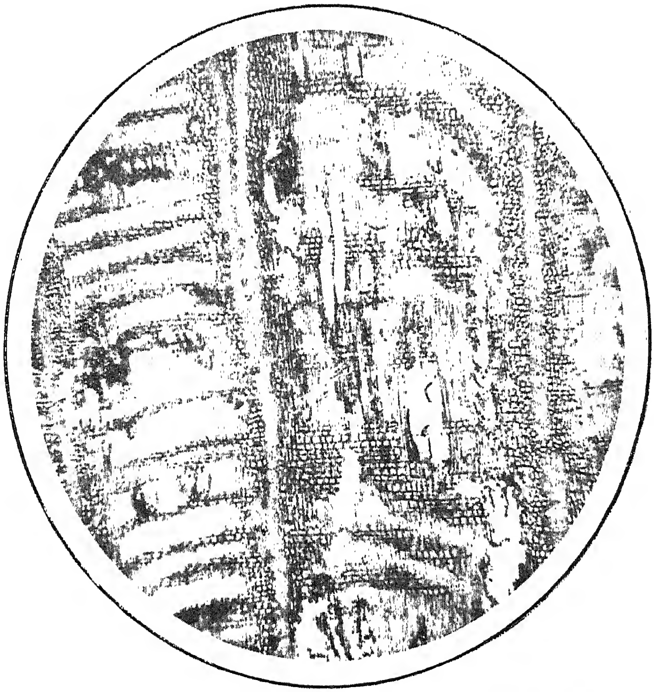
T. C. Roughley, Photo.

Fig. 16.—Transverse section of secondary wood. × 35.
Avicennia officinalis, Linn.



T. C. Roughley, Photo.

Fig. 17.—Tangential section of secondary wood. × 35.
Avicennia officinalis, Linn.



T. C. Roughley, Photo.

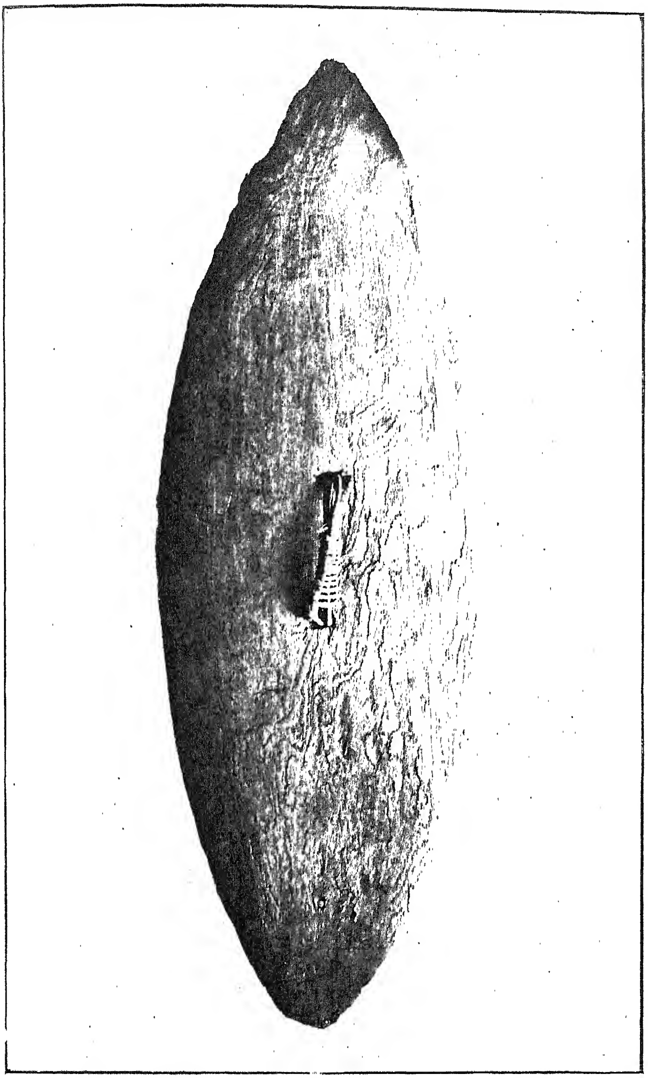
Fig. 18.—Radical section of secondary wood. × 35.
Avicennia officinalis, Linn.

T. Dick, Photo.

Fig. 19.—Seven year's old Grey Mangrove trees, five feet high. *Avicennia officinalis*, Linn.

T. Dick, Photo.

Fig. 20.—Grey Mangrove outspreading over exposed portion of breathing roots.
Avicennia officinalis, Linn.

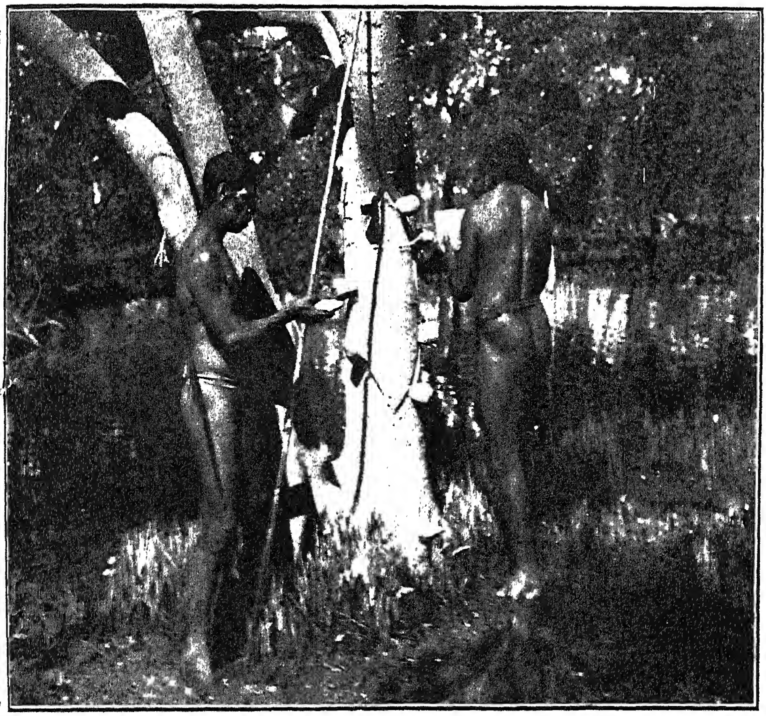


T. C. Roughley, Photo.

Original Heliman or Shield made from "Grey Mangrove," *Avicennia officinalis*, L.

T. Dick, Photo.

Group of Grey Mangroves. Almost all the trees show evidences of shield-cutting.

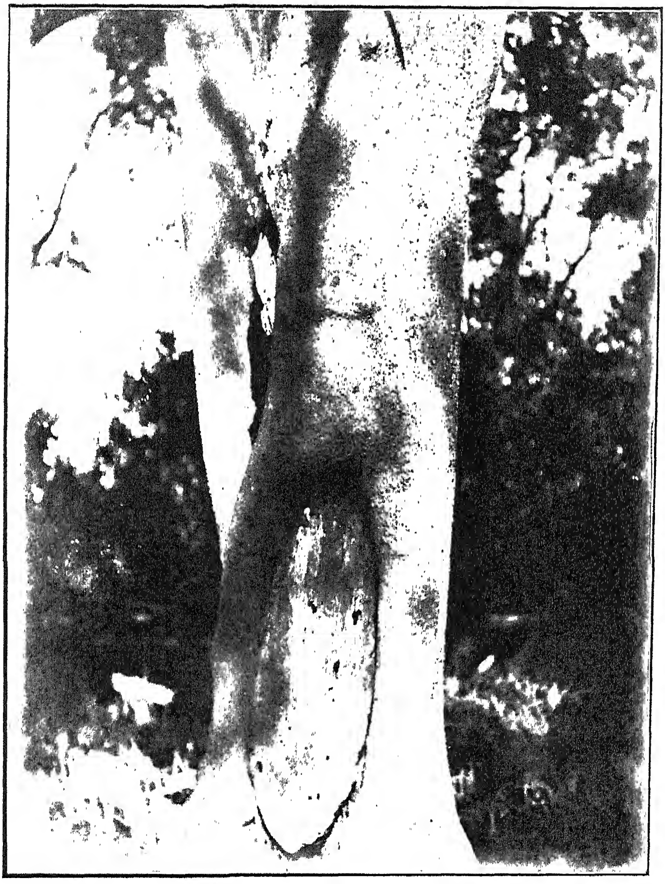


T. Dick, Photo.

Driving original stone wedges into the rabbet. Grey Mangrove, *Avicennia officinalis*, L.

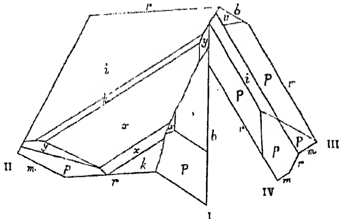
T. Dick, Photo.

Aborigines removing a shield from a Grey Mangrove, *Avicennia officinalis*, L.



T. Dick. Photo.

A fine example of a shield-scar in a living tree.
Grey Mangrove, *Avicennia officinalis*, L.



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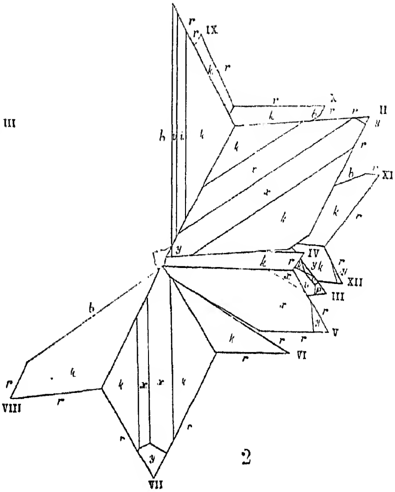

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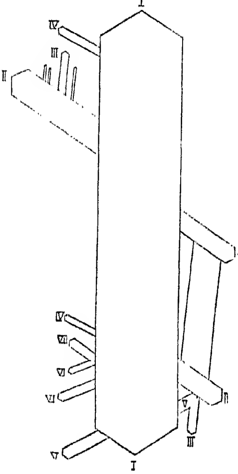

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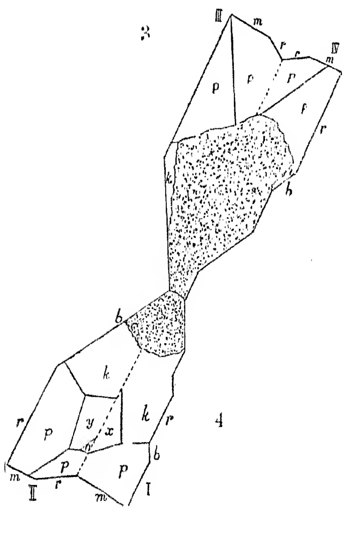

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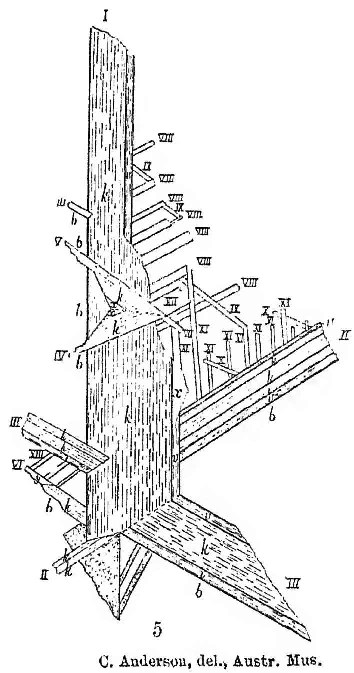

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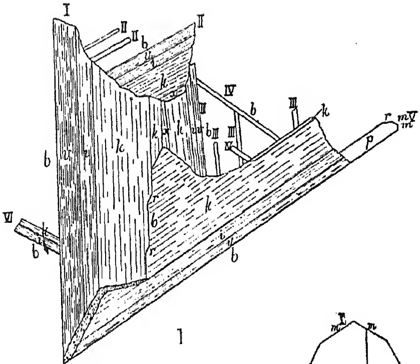
C. Anderson, del., Austr. Mus.



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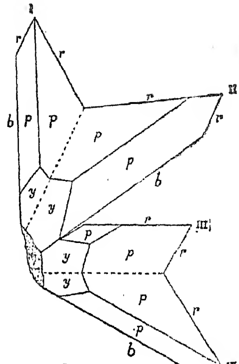

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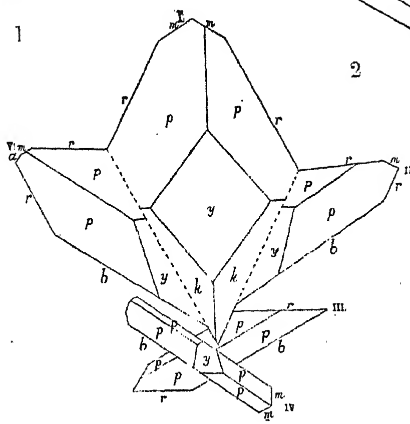

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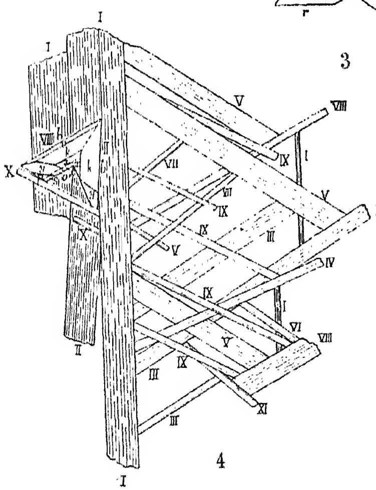

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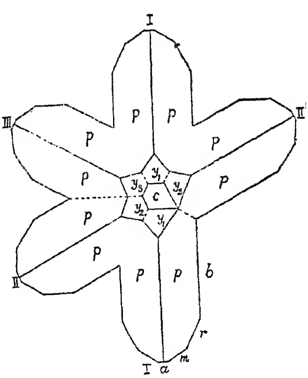

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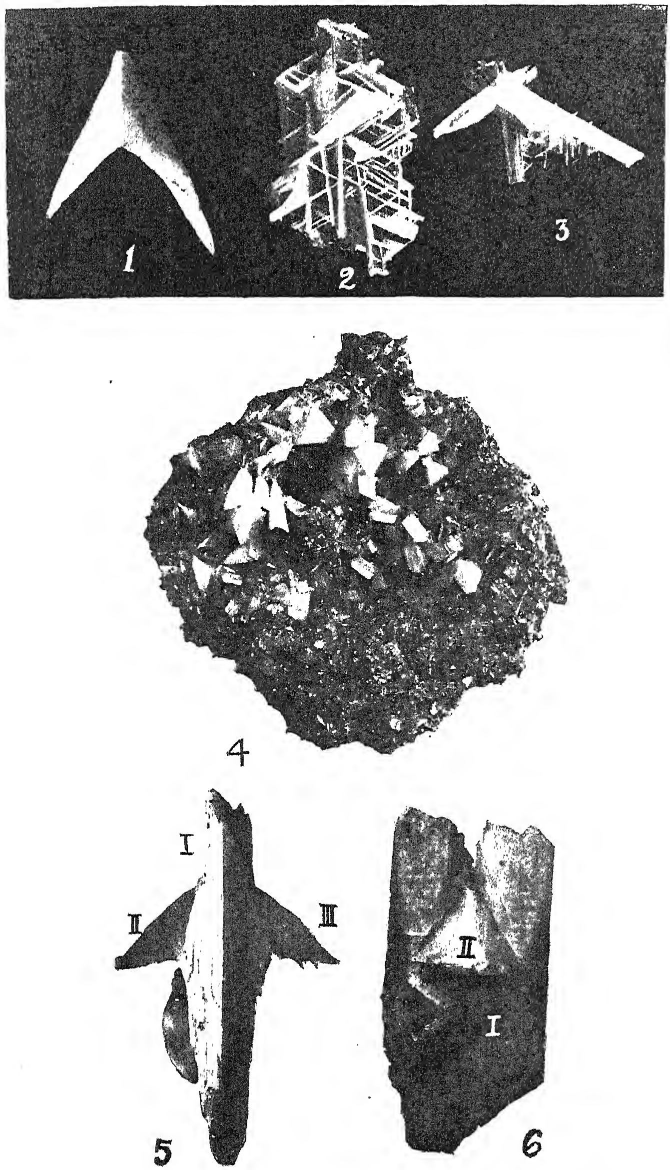
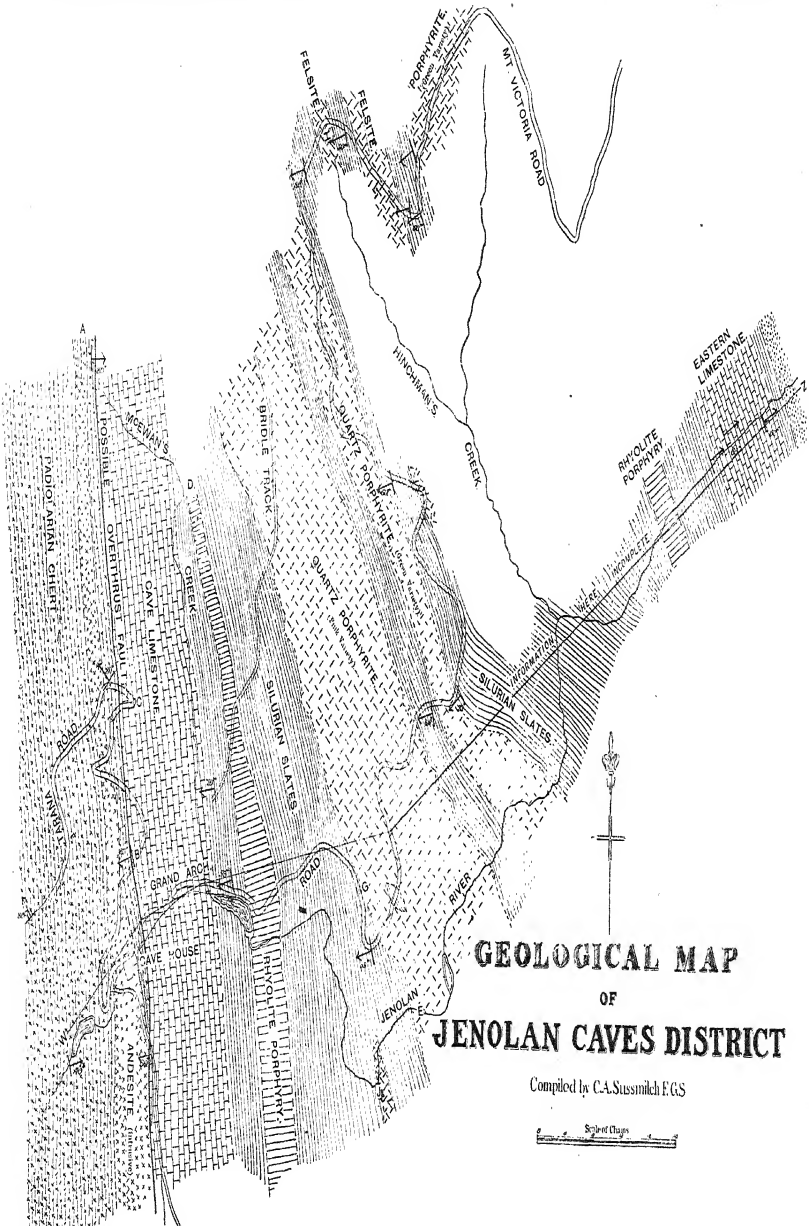
C. Anderson, del., Austr. Mus.



C. Clutton, photo., Austr. Mus.



GEOLOGICAL MAP
OF
JENOLAN CAVES DISTRICT

Compiled by C.A. Sussmilch F.G.S

Scale of Chains

Silurian Limestones, Jenolan Caves, showing the eastern end of THE GRAND ARCH.

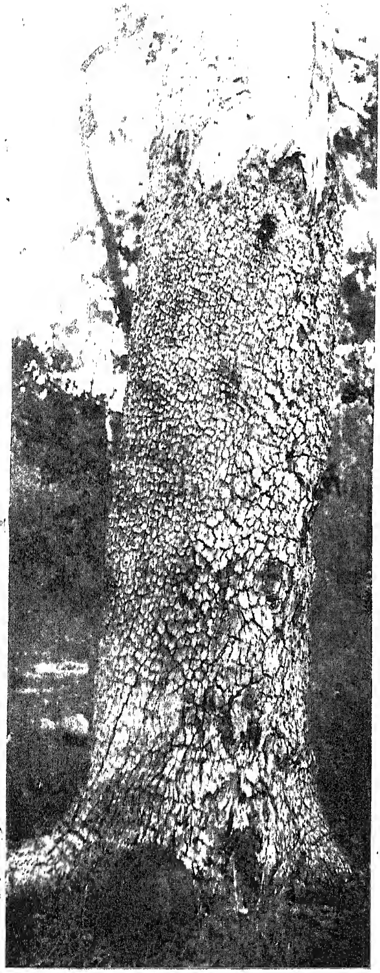


FIG. 1.—*Eucalyptus clavigera.*

FIG. 2.—*Eucalyptus papuana.*

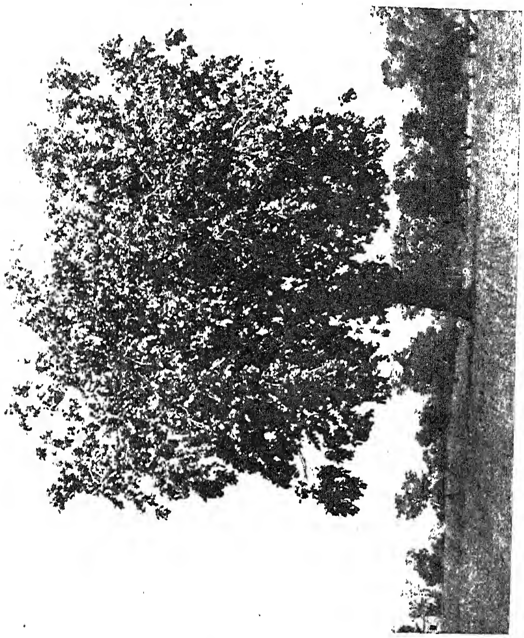


FIG. 2.—*Terminalia platyphylla.*

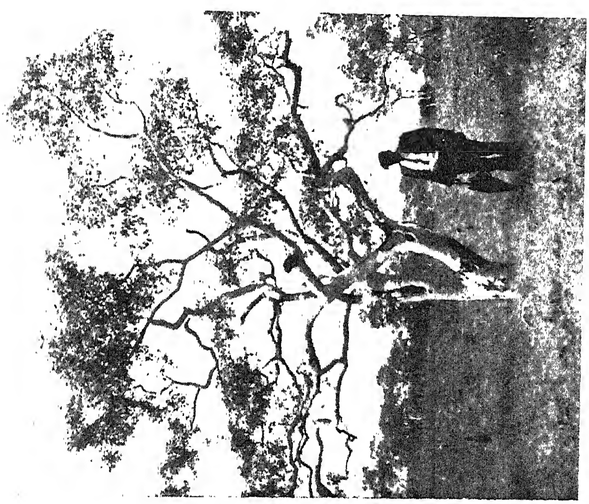
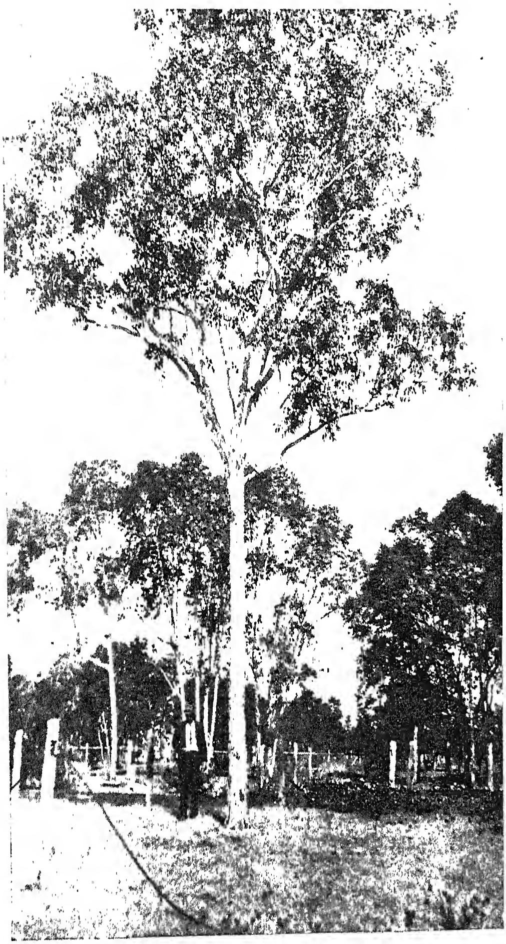


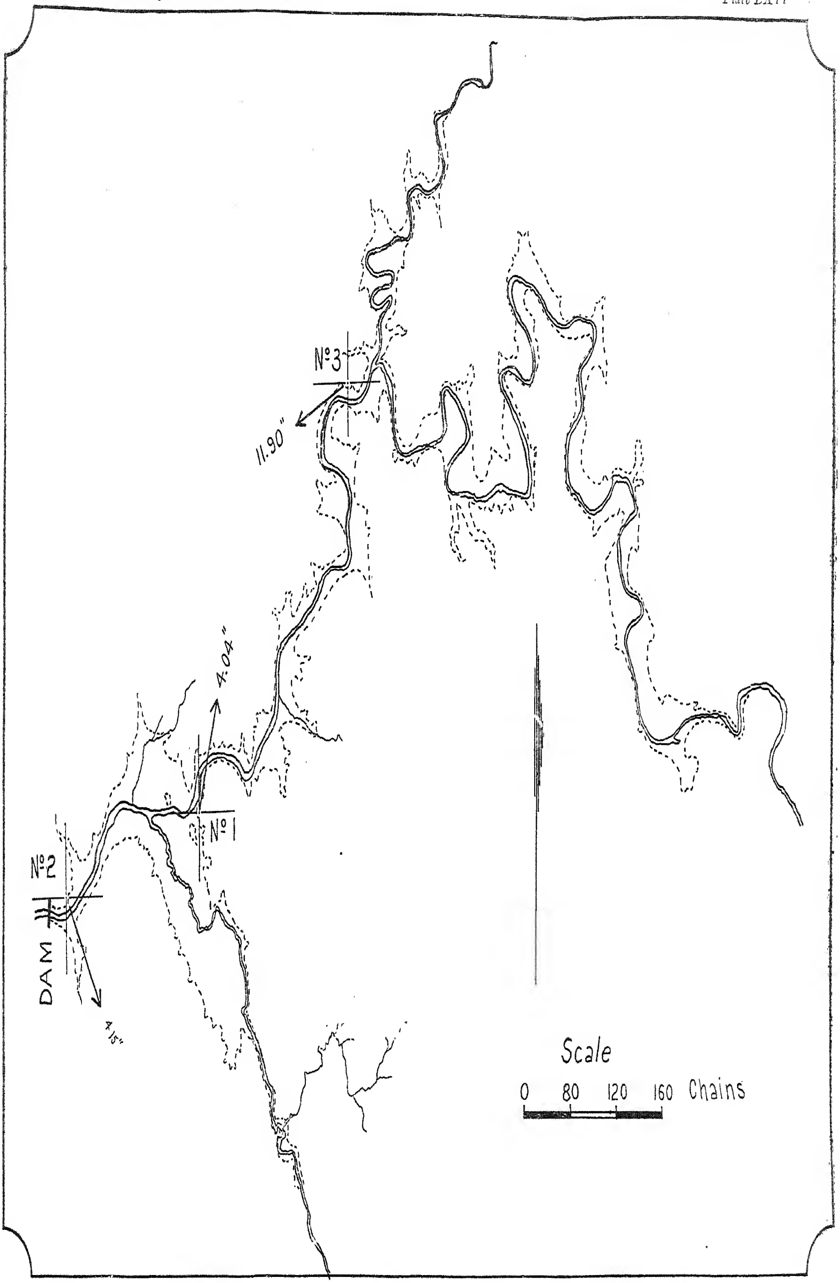
FIG. 1.—*Eucalyptus pallidifolia.*



Eucalyptus miniata.

Acacia Sutherlandi.

Eucalyptus pruinosa.



Nº3
11.90"
4.04"
Nº1
Nº2
DAM
4.15"
Scale
0 80 120 160 Chains

Date of issue.	Date of issue.	Date of issue.